SCIENTIFIC AMERICAN SUPPLEMENT No. 502

Scientific American Supplement, Vol. XX., No. 502.
Scientific American, established 1845.

NEW YORK, AUGUST 15, 1885.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE RECENT BRITISH NAVAL EVOLUTIONS.—THE NIGHT ATTACK ON THE BOOM.

BRITISH EXPERIMENTAL EVOLUTIONS WITH TORPEDOES AND WAR SHIPS.

A SQUADRON of ships of the Royal Navy, "on particular service," has been performing a series of experimental evolutions in Bantry Bay, on the southwest coast of Ireland. The principal ships of the squadron, under the command of Admiral Sir Geoffrey J. Hornby, K.C.B., Vice-Admiral Sir Anthony Hoskins, K.C.B., and Rear-Admiral W. H. Whyte, were the flag-ship Minotaur, seventeen guns, iron ship, armor-plated; the Hercules, fourteen guns, armor plated (flag-ship of Vice-Admiral); the Agincourt, seventeen guns, armor plated (flag-ship of Rear Admiral); the Sultan, twelve guns, armor plated; the Iron Duke, fourteen guns, armor plated; the Shannon, nine guns, armor plated; the Devastation, four guns, iron turret-ship, armor plated; the Ajax, six guns, armor plated turret-ship; the Lord Warden, eighteen guns, armor plated turret-ship; the Polyphemus, steel torpedo ram; the Hecla, six guns, iron torpedo depot ship; the Conquest, fourteen guns, corvette, steel and iron, cased with wood; the Mercury, ten guns, dispatch gun-boat; the Mariner, eight guns, composite sloop; the Racer, eight guns, composite sloop; the Penelope, eleven guns, iron armor plated ship; the Leander, ten guns, steel, second class steam cruiser; the Repulse, twelve guns, armor plated ship; and the Oregon, armed cruiser.

On the north side of Bantry Bay, inside the promontory of Black Ball Head, lies Bere Island, five miles long, separated from the main shore by a strait, not much above one mile wide anywhere, called Berehaven, which is very much narrower at the western entrance. It was here, on Monday and Tuesday, June 29 and 30, 1885, that the operations were brought to a conclusion. They were designed chiefly to test the powers of the small craft of a modern fleet—torpedo launches, steam pinnaces, and ships' boats—in an attack on a squadron driven to take shelter in harbor from a superior force. For the purposes of this experiment Admiral Hornby divided his fleet into two parts, the defending vessels, commanded by Rear-Admiral Whyte, lying in Berehaven, Bantry Bay, while the attacking squadron, under Vice-Admiral Hoskins, was stationed further up the bay at Glengariff Harbor.

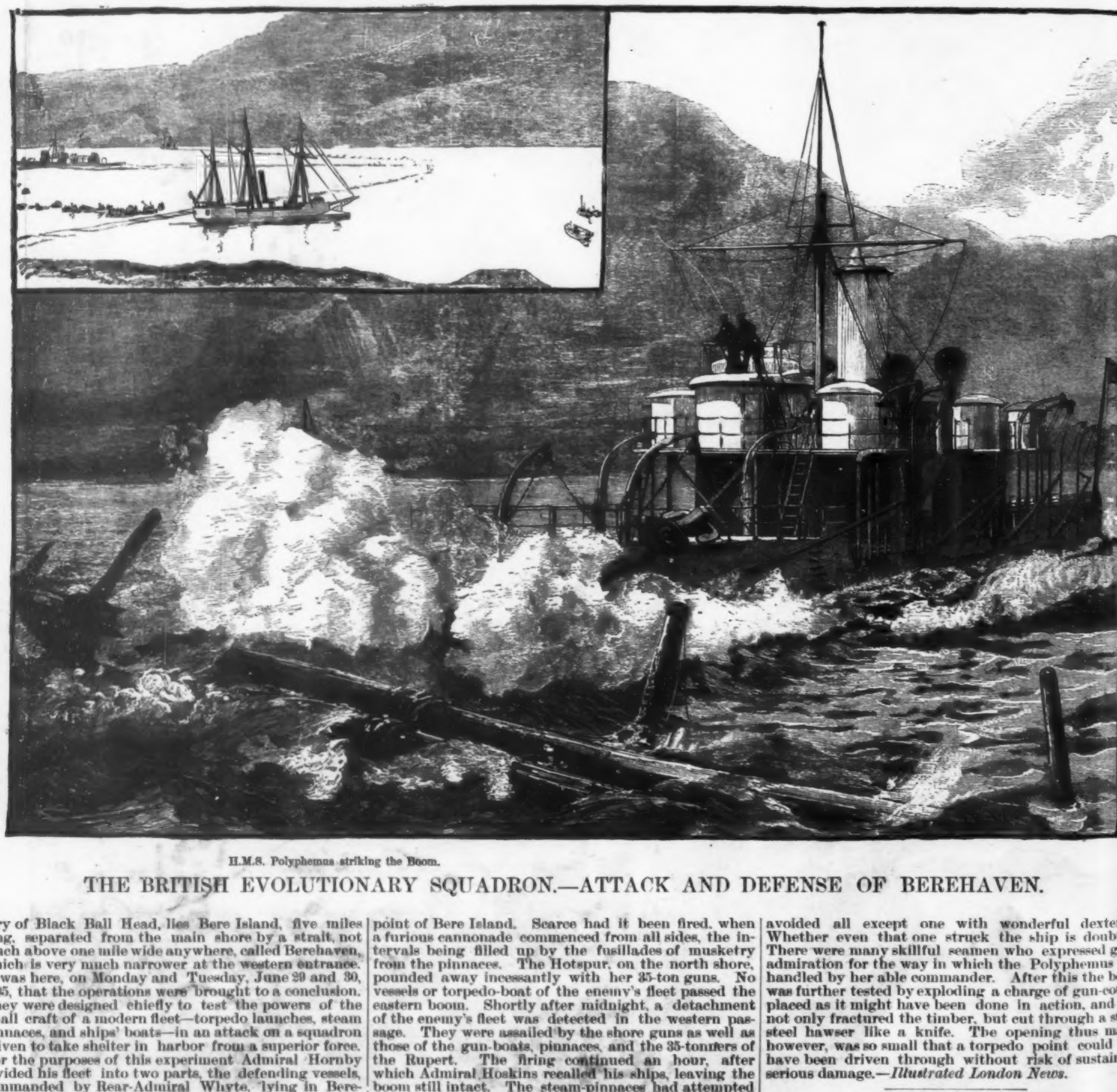
From the eastern and western ends of Bere Island booms had been built to the mainland, thus closing the channel where the defending squadron lay to anything but large and heavy vessels. These booms, supported by fields of mines laid down in the outside waters, and cables and ropes placed in such a manner as to foul the screws of the advancing flotilla, and aided by such additional conditions as powerful electric lights and clear weather, proved to be practically impregnable against the onslaught of the "wasp" squadron which assailed them on the Monday night.

The harbor of Berehaven, with Bere Island, which was occupied by six hundred seamen and marines, with field and machine guns, was supposed to be held by Rear-Admiral Whyte, while the mainland or northern shore was regarded as inaccessible. The gun-boats Medway and Medina, with the torpedo-ship the Hotspur, guarded the eastern boom; and the Snap and Pike gun-boats, with the Rupert (torpedo-ship), held the western boom. In such an encounter, by the rules of the game, a boat will be put out of action if she is in the beam of an electric light, and is under the fire of a field or heavy gun at ranges up to 600 yards for ninety seconds, or at ranges up to 1,200 yards for two minutes. She will also be put out of action by machine-gun fire within 600 yards for two minutes, or if she passes within 30 yards of a hostile boat of superior force, or if she passes within 30 yards of two inferior hostile boats of equal force. They will put one another out of action if they pass within 30 yards of one another. Gun-boats may be put out of action by being struck by a torpedo; the large ironclads may be similarly disabled. The Whiteheads are used without explosive charges, but carry the Holmes light, which shows the direction of the weapon. Any ships put out of action must immediately extinguish their electric lights. They need not, however, recall their boats.

The grand attack began at a quarter past eleven at night, when red lights were sent up by the gun-boats guarding the eastern boom announcing that the torpedo-boats which had been sent out reconnoitering had sighted the advance of Admiral Hoskins' fleet. Some extra torpedo-boats were sent out, and the alarm was given by a shot from the long-range gun on the eastern point of Bere Island. Scarce had it been fired, when a furious cannonade commenced from all sides, the intervals being filled up by the fusillades of musketry from the pinnaces. The Hotspur, on the north shore, pounded away incessantly with her 35-ton guns. No vessels or torpedo-boat of the enemy's fleet passed the eastern boom. Shortly after midnight, a detachment of the enemy's fleet was detected in the western passage. They were assailed by the shore guns as well as those of the gun-boats, pinnaces, and the 35-tonners of the Rupert. The firing continued an hour, after which Admiral Hoskins recalled his ships, leaving the boom still intact. The steam-pinnaces had attempted to "jump" the boom, and three of them got over, under a heavy fire, but were captured inside.

On the Tuesday afternoon, H. M. S. Polyphemus went out alone to try what effect a fast steam-ram of her class would have going at highest speed full tilt against the boom, with all its bristling spars and entanglement of wire hawser. For the spectacle of this trial, a great concourse of torpedo-boats, launches, cutters, and other small craft began to collect near the center of the eastern boom. Admirals Hoskins and Whyte went thither in their galleys; and the Commander-in-Chief followed them in a steam-pinnace, accompanied by Captain Fisher, of the Excellent. The boom was guarded by a line of torpedo-boats moored so as to enfilade the boom, just within effective rifle range. The Polyphemus had to run the gantlet of this formidable aray, and one would have thought her chances almost hopeless. Going a mile or two outside the harbor mouth, she gradually got up speed, as she circled round and round like an eagle in flight ready to swoop on its prey. As her speed increased up to seventeen knots or more, pointing straight for the defensive works, she seemed to skim over the water. As she passed across the submarine mines, several electric contact batteries exploded, showing that they had been well laid, and had sustained no injury during their long immersion in the water. Gathering way as she went, the Polyphemus shot clear of two torpedoes well aimed at her, and ran for the boom. A moment of anxious suspense, and then she crushed through the obstacle as if it had been of paper, severing the five-inch steel wire hawser without the slightest difficulty or any shock or pause, so irresistible was the force of her rush. A third torpedo was aimed at her, but Captain Jeffreys, who handled his ship with great skill and coolness, merely ordered the helm to be put hard-a-starboard. She swung quickly round, and the frightful missile, instead of striking the Polyphemus, fell on her quarter and passed harmlessly astern, while those on board raised a hearty cheer for the clever maneuver by which this shot had been avoided. Then a perfect armada of steam-launches carrying torpedoes swarmed about her, discharging those engines as they came, so that they crossed the tracks of each other. Pursuing similar tactics throughout, Captain Jeffreys turned his ship now right, now left, stopped her dead, or went ahead full speed, as occasion demanded, and avoided all except one with wonderful dexterity. Whether even that one struck the ship is doubtful. There were many skillful seamen who expressed great admiration for the way in which the Polyphemus was handled by her able commander. After this the boom was further tested by exploding a charge of gun-cotton placed as it might have been done in action, and this not only fractured the timber, but cut through a stout steel hawser like a knife. The opening thus made, however, was so small that a torpedo point could not have been driven through without risk of sustaining serious damage.—*Illustrated London News.*

The Boom after it was broken by H.M.S. Polyphemus.

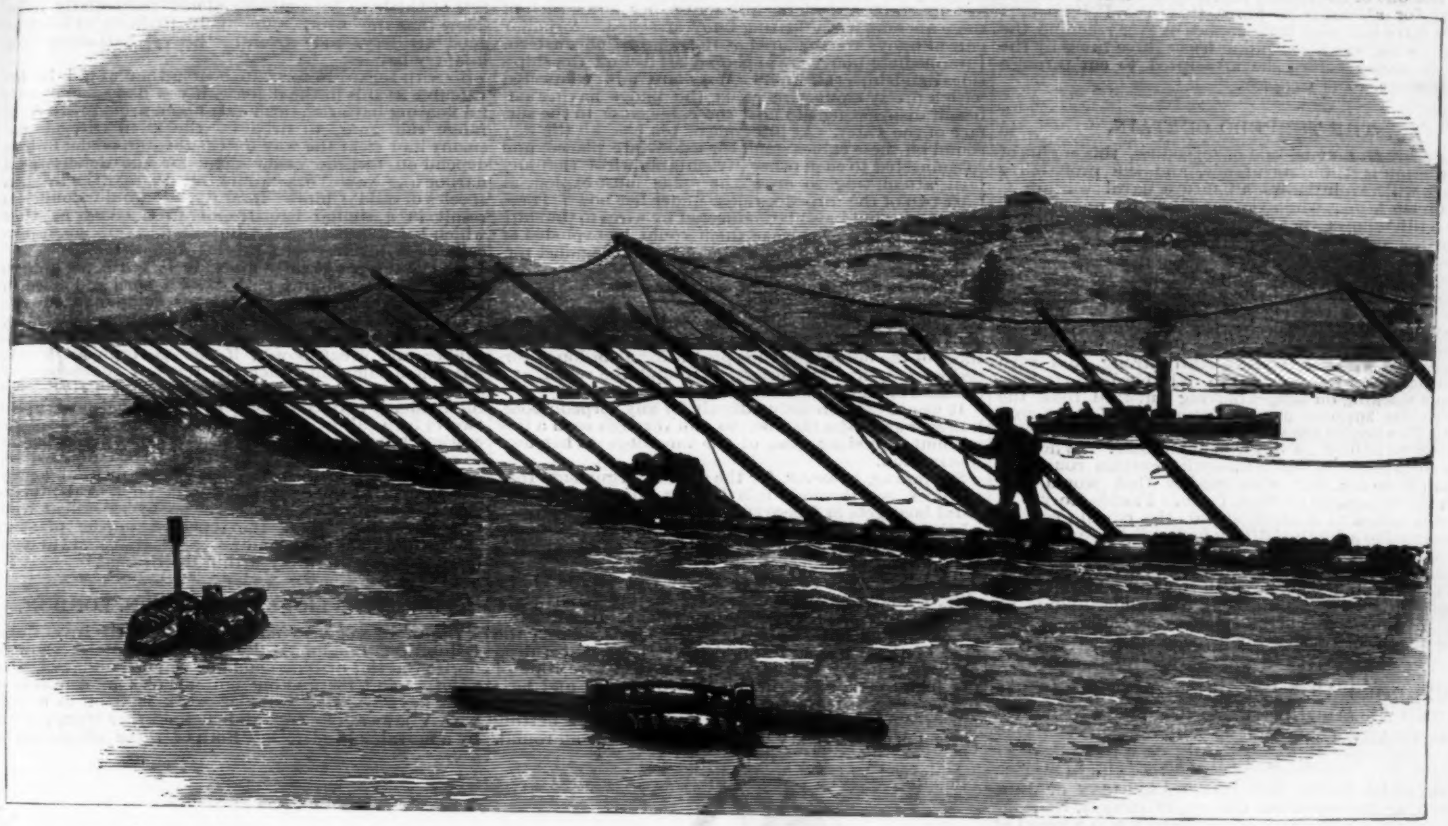


H.M.S. Polyphemus striking the Boom.

THE BRITISH EVOLUTIONARY SQUADRON.—ATTACK AND DEFENSE OF BEREHAVEN.

THE POLYPHEMUS.

PERHAPS the most interesting experiment of the Bantry evolutions was the successful attempt of H.M.S. Polyphemus to get through the defensive boom. It was, indeed, an extraordinary sight to see this vessel getting up the necessary speed, making hither and thither in the water like some huge sea monster, the waves breaking over her in white foam as she lashed through the waters. At last she made straight for the boom, her nose and funnel alone showing out of the enormous wave that her speed created. Then she passed through it without any palpable shock, severing the steel hawser and thick masts like a knife cutting through butter. Her difficulties were not over then, for several torpedo boats dashed at her, and shot their destructive missiles on all sides, but her gallant commander, Captain Jefferies, so skillfully steered her



THE BRITISH NAVAL EVOLUTIONS.—A SECTION OF THE BOOM READY FOR THE ATTACK.

THE BRITISH NAVAL EVOLUTIONS.—THROWING OUT TORPEDO NETS TO PROTECT THE SULTAN.

that not one of the deadly shafts struck her. It may be useful for alarmists to know that the Polyphemus would have had very little chance of ever reaching the boom, as she was blown up at least three times by the contact mines before she attempted to cut through the defenses.—*The Graphic.*

THE TORPEDO CURTAIN.

WHATEVER may be said of torpedoes, this engine of destruction is still in its infancy, and the probability that it will revolutionize all future naval warfare is still on the *tapis*, whatever may be the uncertainty that still follows the erratic movements of some of these destructive missiles. However we may sneer at the curious behavior of the present torpedoes, science is ever at work, and therefore it is necessary to keep a vigilant watch, and to protect our ships as much as possible from a too close acquaintance with those "Davy Jones' locker" persuaders. The majority of the ships with the late Evolutionary Squadron were protected with wire netting sufficiently strong, and with resisting power to explode the Whitehead torpedoes. Booms working on hinges moving outward from the ship's sides support curtains composed of stout iron rings. The booms are worked by pulleys from inboard, and can be hauled up or down at pleasure. When up they form festoons like a mosquito curtain round an Indian bedstead, but with meshes that would defy even the mosquitos of Mark Twain's Florida story. In a few minutes, at a given signal, the curtain can be submerged to a depth of fifteen feet, a distance sufficient to intercept the rush of a Whitehead. My sketch represents H. M. S. Sultan casting round her this nautical zeriba. The blue jackets, with their usual agility and adaptability to any kind of novel undertaking, almost hang on by their eyelids and toes while they spin their net to catch the lively torpedo.—*The Graphic.*

TORPEDOES AND TORPEDO BOATS CONSIDERED AS A SOLE MEANS OF DEFENSE FOR SEABOARD CITIES.

By M. P. HAYES.

THE article in the SCIENTIFIC AMERICAN of June 6, inviting discussion on the above subject, leads me to give you a description of a plan by which a vessel at anchor may be effectually protected from the attacks of torpedo boats.

We will take the case of any of the large ironclads of European navies which you have enumerated, say, for instance, the British ship Inflexible. Let us suppose her to have come up into soundings near enough to Sandy Hook or Coney Island to enable her to throw shells into Brooklyn, New York, or Jersey City. I am not presuming that she could do this if the harbor were properly protected, but it is certain that under existing circumstances she could do so; and the question is, to consider whether a numerous fleet of small, swift torpedo boats, without the aid of powerful land and floating batteries, would be sufficient to prevent her from so anchoring in the first place, or, after she had anchored, to blow her up or sink her.

With regard to the first condition, that is, of a hostile fleet approaching the coast for the purpose of bombardment, I am of opinion that the large vessels of the fleet can be effectually protected from torpedo boats by a numerous convoy of small steam launches kept circling round the ships, armed with short breech loading guns, sufficiently powerful to penetrate with shells the sides of ordinary torpedo boats at short range. These steam launches would also carry small spar torpedoes, which could be used with good effect against the approaching torpedo boats of the coast. They would also be supplemented by a few small, swift, armored ram tenders, which could aid very materially in the defense of the large ships by running down the hostile boats.

I think, with such assistance as would be afforded by six or eight steam launches so armed, and three or four small ironclad rams of good steam power, one of the large ironclads would have no great difficulty in beating off any number of torpedo boats that might try to prevent her from anchoring. Of course the number, size, and power of the launches would have to be proportioned to the number and speed of the torpedo boats likely to come out, and the gun boats and rams would have to proceed sufficiently far in advance of the ship to meet and intercept such of them as might escape the shot of her own long range rifles. I have no faith in any machine guns to keep off torpedo boats; even the 55 mm. Hotchkiss or Gatling, though it may penetrate the sides of a boat, and do a good deal of mischief, will not stop her. The only way in which you can really stop a torpedo boat is by blowing up her boiler with a pretty heavy shell, or running her down with a ram; you might, of course, blow her up with another torpedo, but she may be going too fast for that to be possible. The launches, however, could be so placed that any approaching boat must pass within quite short range of their guns; and if they were numerous enough, the torpedo boats would stand a poor chance of passing with impunity, supposing any of them to have run the gantlet of the rams, which would be naturally stationed in advance of the launches.

It is, in fact, almost certain that a hostile fleet approaching New York harbor could so completely blockade the front of the harbor, in advance of the heavy ships, with steam launches, small gunboats, and swift steam rams, that no torpedo boats could get out to sea at all, much less approach near enough to any of the heavy ships to attach torpedoes to them.

It comes, then, to this, that notwithstanding any number of swift torpedo boats that might be in the harbor, and ready to go out, the hostile ironclads could anchor off Coney Island near enough to shell the cities, if the defense were left to torpedo boats alone.

We will now consider the case of the Inflexible, as one of the ships so anchored and engaged in bombarding the city. Is it possible to so protect the ship that she would be reasonably safe from the attacks of torpedo boats that might escape the vigilance of her outlying sentries and picket guards of launches, gunboats, and rams?

The Inflexible is, say, 325 feet long and 72 feet wide, or thereabout. She is at anchor in, say, 10 fathom water. At a distance of 200 feet in front of her bows she drops two small kedges or mushroom anchors, 472 feet apart, in a straight line across her bows; each of these anchors has a floating buoy attached. A similar pair of buoys are anchored at the same distance astern. Intermediate buoys are anchored 200 feet off the ship's sides amidships; all these buoys are now connected with a pretty stout wire cable, the buoys having sufficient displacement to float the cable close to the surface of the water. At intervals of ten feet all the way round on these cables small torpedoes are placed, and so connected to each other by suitable wires that any boat attempting to cross the cable must explode at least two of the torpedoes close under her bows. These torpedoes would also be connected by wires to the ship, so that any one or more of them could be exploded at will. This forms the outer line of defense against torpedo boats.

The next line is formed of a similar line of buoys and torpedoes, placed at a distance of one hundred and twenty feet from the ship's side, and having its torpedoes so placed that they come in the intervals between those of the outer line, thus presenting a cordon of torpedoes only five feet apart, all round the vessel, at a distance of one to two hundred feet.

It would be extremely difficult for any torpedo boat, however swift she may be, to run through such a line without exploding some of the torpedoes to her own destruction.

Supposing, however, for the sake of argument, that she does get through this line, or that a second or third boat gets in where their predecessors had exploded the torpedoes and broken the line, they would only do so to encounter the real circle of defense, which I would make as follows:

At distances of twenty to thirty feet all round the ship, I would have very stout swinging booms sixty feet long by twelve to eighteen inches in diameter, suspended by suitable tackle to the masts. From the ends of these booms I would have suspended a deep and very heavy netting of flexible steel wire rope of one inch to one and a half inches diameter, and having at short intervals stout wire cables attached to mushroom anchors, so placed as to keep the netting perpendicular at sixty feet from the ship all round. The netting should be deep enough to reach several feet below the bottom of the ship, to resist submarine boats or torpedoes. Then a close line of automatic exploding torpedoes should be attached to the upper line of this netting in such way that no boat could touch the netting without being exposed to an explosion at very close quarters.

The dimensions of the ship being as stated, it will be seen that the material for this system of defense could quite easily be carried on board the ship, and would not seriously interfere with her other loading or equipment. The large booms would be the most cumbersome part of the equipment; twenty of them would have to be carried on the spar deck or slung alongside under the channels; they would weigh ten tons. The wire cables for the two outer lines would be stowed in coils in the hold; they would weigh seven tons. The wire rope for the inner netting would weigh from thirty to fifty tons, according to the size rope that was used; the mushroom anchors would weigh, say, ten tons. The torpedoes for the cable and netting would weigh, say, fifty pounds each, or about twelve tons in all. Thus the extra weight the system would require to be carried would be approximately eighty tons. If this were found to interfere with the distribution of the weight on board, the whole equipment could be carried in a steam tender.

You will thus see that a hostile fleet could not only blockade your torpedo fleet with an equally numerous and effective fleet of launches, gun boats, and rams, of as good power and speed as your torpedo boats, but each vessel of that fleet could be so effectually protected, by some such devices as I have described as to be practically unassailable by torpedo boats while at anchor in hostile waters.

At to defenses by means of any kind of submarine torpedoes, unprotected by powerful armor-piercing guns on shore or afloat, I think it may be considered almost an axiom that they are of small value, since they can be removed or exploded by countermining and dragging with small boats.

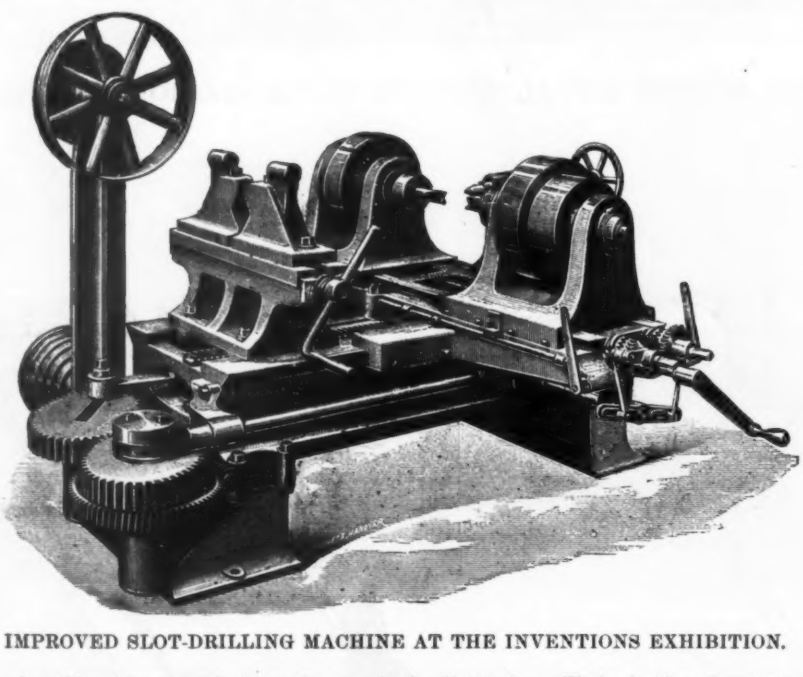
I would not be understood as arguing against the value of torpedoes and torpedo boats as means of defense. On the contrary, they are among the most efficient and powerful of such means, but they are only auxiliaries, just as artillery on land. He would hardly be considered a very wise general who would trust the fate of battle to his artillery alone, particularly if he knew that the enemy were likely to have at least as good artillery, and several "heavy battalions" of infantry besides.

So with regard to torpedo boats; they would be invaluable as aids in the defense, if you had some powerful floating batteries, armorclad and armed with long range rifle guns, to drive off the auxiliaries of the enemy and clear the way for the torpedo boats; but to depend on torpedo boats alone for the defense of a harbor like New York would be, to say the least, a species of mild Chinese insanity. It would doubtless result in a similar catastrophe to the city as that which befell the Celestial Admiral's flag ship, so graphically described in your editorial of the 6th.

On the subject of rifled guns, it is quite possible to get very powerful guns cast of solid steel and rifled in this country. There are several companies in the United States who would be willing, and are quite able, to manufacture excellent rifled steel guns of large caliber and great power, if the government would guarantee sufficient orders to warrant the necessary outlay for plant. Recent improvements in steel casting render it perfectly possible to produce guns up to twelve inch caliber of a solid steel mass, in a single casting, having tensile strength abundantly sufficient to resist any strains they are likely to be subjected to. A good battery of such guns placed behind heavy earthworks at Coney Island would be a real protection to your harbor. There is no armor afloat that can successfully resist the repeated impact of steel shells from such guns, and no vessels that could anchor or approach with safety within their range.

THE INVENTIONS EXHIBITION, LONDON.

Improved Slot Drilling Machine.—At the Inventions Exhibition, London, Hulse & Co., of Salford, show a horizontal slot-drilling machine, which is designed, says *Engineering*, for making cotter holes in connecting rods, keyways, etc. Circular work is held in a vise with V jaws at one end, and at the other is supported by a movable headstock. Both of these are shown in



IMPROVED SLOT-DRILLING MACHINE AT THE INVENTIONS EXHIBITION.

the illustration. Work of other descriptions may be bolted to a grooved table which is placed along the bed, the movable headstock and the vise being removed. There are two drilling headstocks as shown. These operate at both sides of the work, and are provided with self-acting feed and disengaging motions. The sliding carriage is moved along the bed by a crank placed under it, and this is actuated by the elliptical spur-wheels plainly shown in the illustration. The wheels being elliptical give a uniform traverse throughout, whereas if circular wheels were used the angular motion of the connecting rod would affect the speed of travel. The self-acting feed motion to the drilling headstocks is obtained by means of a cam motion above the elliptical driving wheel as shown. The self-acting disengaging motion to each drilling headstock is obtained by means of a sliding rod and claw-clutch, which is also to be seen by reference to the illustration, and which is brought into operation by means of a stop on the headstock.

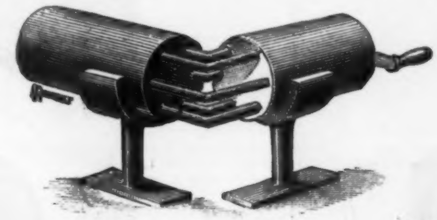
Paper Bag Machine.—There are few more interesting and ingenious objects in the Inventions Exhibition than the paper-bag making machinery shown by Mr. F. D. Bumsted, of Hednesford, in the West Gallery. We give an illustration of this apparatus, which is capable of turning out thirty-eight 1 lb. sugar-bags per minute, the whole operation being automatic, an attendant only being required to remove the bags when made and fill the hoppers with paste at intervals. It would be clearly impossible to give more than an outline description of the apparatus without the help of numerous diagrams. At one end of the machine a continuous roll of paper is placed as shown to the right of the illustration, and as this is unrolled it is carried to the first pasting roller (shown under the hopper above the table), which lays on a continuous strip of paste near one edge. The motion by which the web of paper is unrolled is intermittent, it being stopped in order that another strip of paste may be applied to make the bottom joint of the bag. This is done by a lifter rising and pressing the paper against the transverse pasting roller. Both rollers and the hoppers by which they are fed are shown in the illustration. The paper again passes on until the the proper length to form a bag has been unwound, when it is again brought to rest, and a knife descends, cutting off the requisite quantity. The

piece of paper is delivered on to a star-shaped wheel, which moves through a quarter of a revolution between each stop, and three successive folding operations are effected. This is the most ingenious part of the machine, and at the same time the most difficult to describe, but the way in which the sheets are doubled over, their pasted strips brought against the edges and the corners tucked in, is perfectly effective.

On the same stand a larger machine of another type is shown which will turn out forty large bags a minute. To this machine the paper is supplied by hand in pieces each the proper size and shape to form one bag. The sheets are placed on continuous moving tapes, but as it is necessary that the sheets should be fed to the machine intermittently, vertical pegs are projected from beneath the table to stop the movement of the paper forward, as the tapes are continually running.

Cask-Washing Machine.—Among other exhibits, Messrs. Thornewill and Warham, of Burton-on-Trent, show a cask-washing machine, of which we give an illustration. As may be seen, there are two girder-shaped uprights, connected at the top and firmly bolted to a heavy bedplate. To one of these uprights a spurwheel, to act as a sunwheel, is bolted, and through the center of this wheel the horizontal driving spindle is passed. On the latter are mounted fast and loose pulleys. The inner end of the spindle is connected to a square frame, which is free to revolve in a vertical plane. This is fitted with a strong central shaft, upon which is cut at one end a right-hand screw, and a left-hand screw being at the opposite end. The nuts engaging with these screws are connected with two circular platforms, and by turning the screwed shaft these platforms are made either to approach or recede from each other. In this way the different sizes of casks are accommodated, and are firmly held while being operated upon. One end of the screwed shaft is connected by bevel gearing with a train of planet wheels, which are always in gear with the fixed sunwheel. The action of the machine is as follows: By means of a clutch the central screwed shaft is caused to revolve independently, thus clipping the barrels between the two platforms as described. The clutch is then thrown out of gear and the machine is ready for work. The driving spindle imparts a rotary motion to the square frame, and at the same time the sun and planet wheels cause the central screwed shaft, and with it the platforms and barrel, to revolve rapidly, thus producing a whirling motion. Water and shingle are used in the barrels, and this is found to be all that is necessary, even in the worst case upon which the machine has been tried. The casks are afterward dried by a jet of hot air. The apparatus is shown at work in the Exhibition.

Improved Gas-Fired Kiln.—Another of our illustrations shows a novel description of gas-fired kiln for burning lime, a model of which is being exhibited by the Municipal Appliances Company, of Liverpool. This apparatus has been in use since October, 1883, at Llysfaen, and we understand has proved very successful. Previously to these kilns being erected a series of experiments, extending over eighteen months, were made in order to prove its advantages. Our illustration shows a double kiln, but the two parts are independent of each other, and may be worked separately. The gas from the producers enters the kiln at A, the flow being regulated by valves at B. At C are doors by which the air necessary for combustion enters, the air and gas meeting at DD. The lime is burnt in the chambers, E, and is afterward cooled as it descends in the zones, F, by the air passing in at the lower part. The waste heat is conducted away in the upper part of the kiln through the chimney openings at G. At H are sight holes for judging the heat of the kiln,



IMPROVED SHAFT COUPLING.

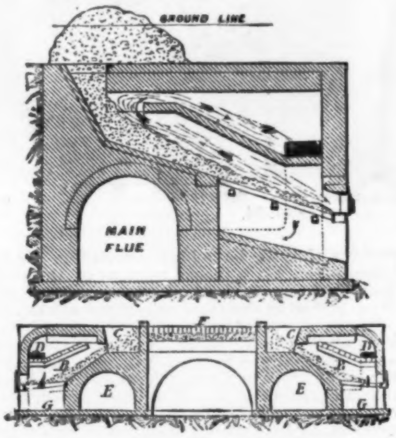
and J are holes to admit air when the flues have to be burnt out. The fuel used in the gas producers is ordinary slack. A special feature is the method of constructing the central partition wall, this having air-cooling and circulating cavities as shown. The lime produced is naturally perfectly free from clinkers, and is much liked for chemical purposes. There is said also to be a great economy in fuel, labor, and cost of repairs as compared with ordinary kilns.

The Destructor Furnace.—Another exhibit shown by the same firm is a model of Healy and Thwaites' Destructor furnace, of which we also give illustrations, one of the views being a transverse section of a double line of furnaces. The grates where the fire is made are shown at A. At B the refuse to be destroyed is shown in an inclined flue where it is being dried, and as it is consumed on the grate, descends on the slope of the flue, fresh matter being supplied from the pits at C. The down flue, by which the products of combustion pass to the chimney, is shown at D, E being the main flue. The vapor which rises from the drying flue passes over a reverberatory arch on its way to the chimney flue, by which means the obnoxious gases are destroyed. Excepting when starting the apparatus, no fuel is required for burning ordinary refuse. The cost of labor is said to be about four pence per ton, when three or more furnaces are worked conjointly, and each furnace will reduce to clinker fifty tons of refuse per week. The charging openings at the back end of the furnace are covered by strong lintels of metalline or cast iron. The reverberatory arch is built with tongued and grooved fire lumps, and the charging hole lintel protects this arch from the firing tools. The firebars of iron are similar in section to coal-screen bars, and have distance-pieces about 1 ft. apart, which keep the bars ⅜ in. clear on the top side. In another arrangement the grate has moving bars which come forward altogether, one-half only going back at once. In this way the clinker is brought forward and delivered into a receiver place for the purpose.

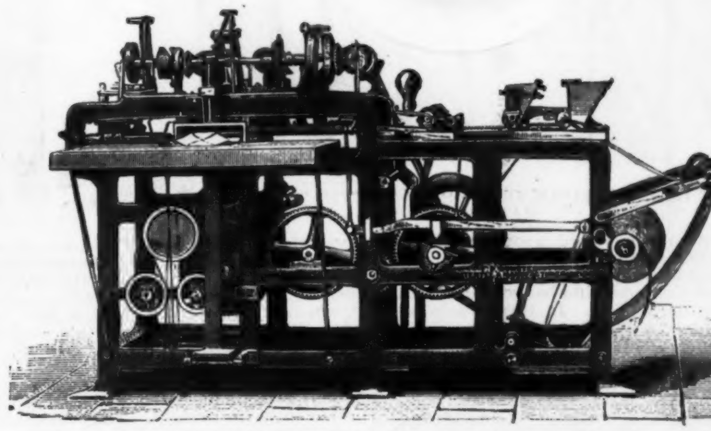
Improved Shaft Coupling.—Few of the smaller objects in the Inventions Exhibition, London, have attracted more attention or evoked more kindly interest than the coupling for the transfer of rotary motion from one shaft to another, exhibited by Lieutenant-Colonel D. R. Cameron, R.E. It is so seldom, says *Engineering*, that a new mechanical motion is invented, that its appearance is received with pleasure, quite apart from any merits that it may possess on the score of its usefulness, and the mere ground of its originality entitles it to distinction, even when it is shown among complicated machines, which are capable of carrying out processes that almost seem to demand the power of thought.

The coupling is shown by the annexed sketch, which represents the principle on which it works rather than a practical method of carrying out the idea. The two shafts are inclined to each other at an angle, in this case at a right angle, and they are bossed up at their ends to receive the coupling appliances. These enlarged ends are each bored with six holes arranged in a circle, and in these are fitted plungers free to slide in and out. Each plunger is bent at a right angle at the center, so that one end can enter a hole in each shaft, and thus these holes are coupled in pairs. Now, if one shaft be rotated while any or all of these plungers are in position, it is evident that each of the plungers which are in it must go round with it. But the opposite ends of the plungers are in the second shaft, and this latter must also revolve to allow of the motion of the first. As each pair of recesses stand at right angles to each other in all positions, the same bent plunger will connect them equally well at all parts of the revolution, the only accommodation required being that the plungers shall slide in and out of the recesses according as the openings of the latter come nearer together or farther apart. The result is that the motion of the first shaft is conveyed to the second with perfect uniformity without dead points.

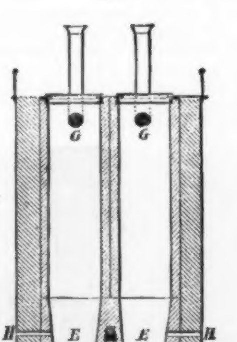
The same device is capable of converting reciprocatory into rotary motion. If each of the recesses be conceived to be a steam cylinder to and from which motive fluid is alternately admitted and exhausted, it will be seen that both shafts must rotate. Of course it needs no great skill in mechanics to enable a person to raise



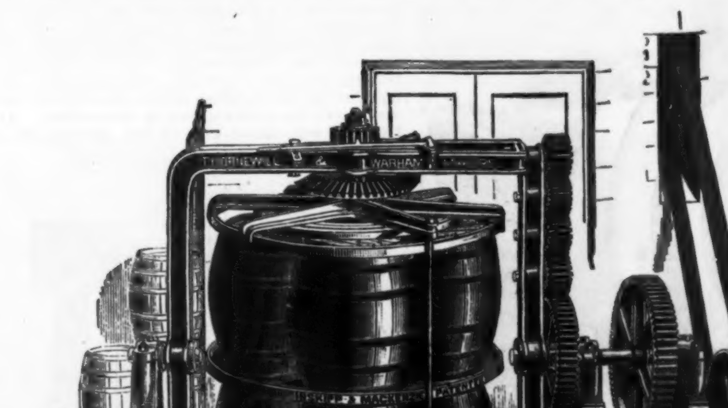
HEALY & THWAITES' DESTRUCTOR FURNACE.



BUMSTED'S PAPER BAG MAKING MACHINE.



GAS-FIRED LIME KILN.



THORNEWILL & WARHAM'S CASK WASHING MACHINE.

EXHIBITS AT THE INVENTIONS EXHIBITION.

very weighty objections against the use of this new motion, and we do not reproduce it with the idea that it will replace bevel wheels and similar appliance; it is, however, a notable curiosity, and as such it cannot fail to interest the scientific mechanic.—*Engineering.*

A NEW SYSTEM OF TELEPHONIC COMMUNICATION.*

THE apparatus shown in Fig. 32 offers the peculiarity that the magnets of the call have been utilized at the same time for the telephone transmitter. The

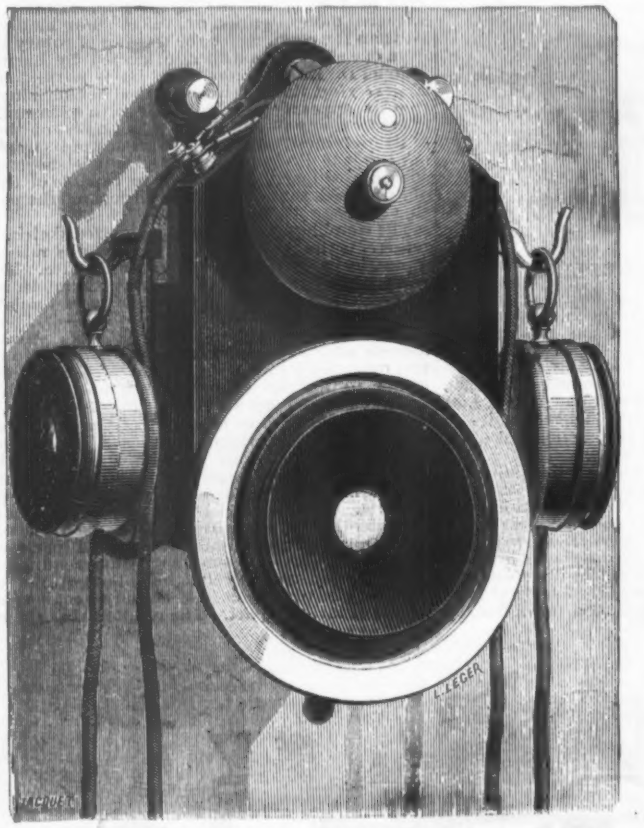


FIG. 32.—A COMPACT FORM OF THE MAGNETIC TELEPHONE.

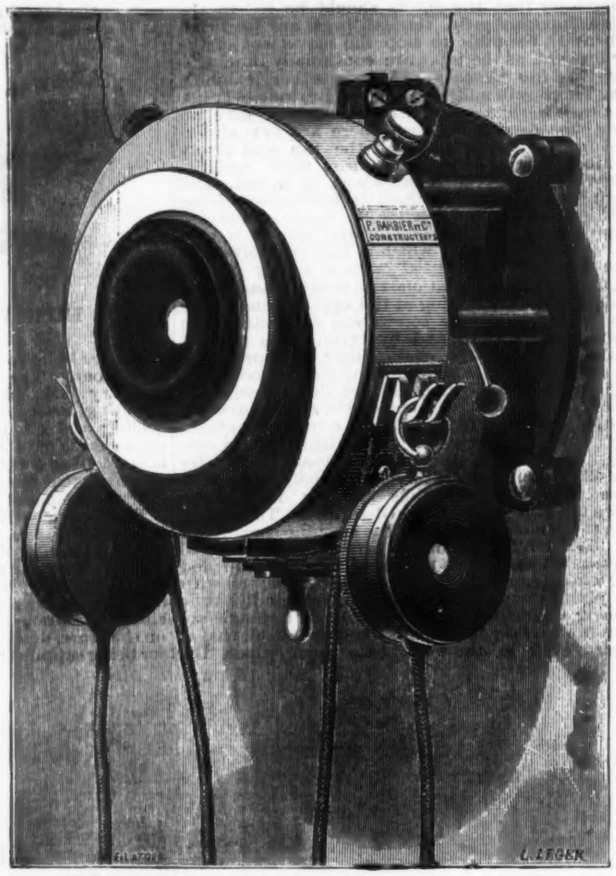
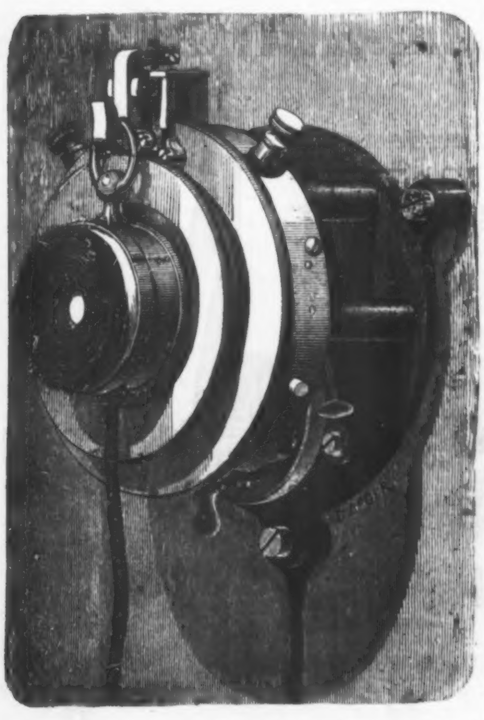


FIG. 34.

bobbins of this latter are mounted upon pieces of soft iron fixed to two of their poles. Much space is thus gained, without any loss of power in the apparatus.

A combination of the same kind has served as a base for another apparatus (Fig. 33). In this arrangement there is employed only a telephone receiver, which in a state of rest is suspended in front of the transmitter and conceals it.

Finally, the most recent model is shown in Fig. 34.



FIGS. 33 AND 34.—MOST RECENT FORMS OF THE MAGNETIC TELEPHONE.

This apparatus is most remarkable in its operation. Upon speaking at five feet from the transmitter without lifting the voice, one can make himself heard in the receiver with astonishing clearness and intensity. This telephone presents a few arrangements that differ from those that we have hitherto noted. Thus, the automatic commutator is no longer the same. We have seen that the current produced by the call is sent alternately into the line through two elastic contacts, each of which operates during a half-oscillation of the apparatus. The commutation from one to the other was made in the previous cases while the bobbin was passing through its mean position, but here it occurs at the moment when, having reached the end of its swing, it stops before moving back. In fact, the two contacts, F F (Fig. 27), are fixed to a piece of movable wood, U (Fig. 35), which revolves with somewhat hard friction around a screw, V, that holds it against the frame of the apparatus. This piece, U, occupies, relatively to the spring, R, the same position as the piece of wood, H, in the first commutators. It contains an aperture which allows of the passage of a projection, P, which is soldered to a piece, X, that surrounds the spring, R. In a normal state, this projection does not touch either of the springs, F and F. These latter bear against a pin, H, inserted into the wood, U, and serving to connect them. The two extremities of the bobbin wire are insulated, and neither of them is connected with the weight. They communicate, respectively, with the springs, F F, at which also terminate the line wires. It will be seen, then, that in a state of rest the bobbin of the call will be in short circuit. The current sent by the apparatus with which a subscriber is connected will not traverse it, but will go directly from one of the springs, F, to the other, through the intermedium of the pin, H. On the contrary, when the bobbin is made to oscillate, the projection, P, will abut against one of the sides of the aperture in the piece, U, and carry the latter along in its motion. At the same time it will move one of the springs, F, away from

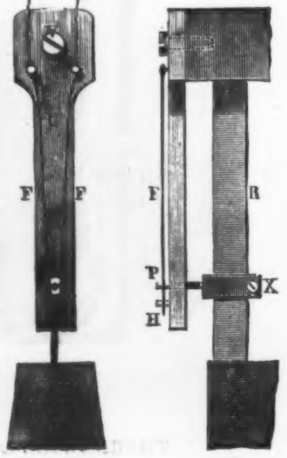


FIG. 35.

the pin, H. The short circuit will thus be broken, and the current produced will go into the line. Reaching the end of its travel, the piece, U, will stop, the projection will return and abut against the other edge of the aperture in U, the first spring, F, will at the same time return to its initial position, while the second is away from the pin, H; the piece, U, will be carried along again, but in a direction contrary to that of its preceding motion, and the play of the apparatus will continue in the same way until the oscillation of the bobbin is arrested, and the piece, U, has taken its first position again.

The bell, S (Fig. 37), is mounted in series with the call. In a normal state, the contact, A, is closed, and the contact, B C, is open. It will be seen that, when the call is operating, the bell of the apparatus that is calling is actuated as well as the one of the station that is called. In certain cases, such an arrangement may have its advantages.

Fig. 38 gives a diagram of the connections of the apparatus that we have been describing. In reality, the transmitter, Tr, is placed in front of the call, which is itself in front of the bell. In our figure we suppose them placed in the same order, one above another.

The contact, B C (Fig. 37), is obtained by means of a lever analogous to those described above, and which acts in such a way as to simply open the circuit from B to C (Fig. 38), when the telephones are in place. Between A' and G the circuit is interrupted, but at A' and G there are two hooks which are insulated from one another, and which are designed to receive a telephone. When one of the receivers is hooked on, its ring sets up a communication between one of the hooks and the other.

The lever, C, is placed between the hooks, A' G, so that the same telephone, on opening or closing the circuit from B to C, will, on the contrary, close or open the circuit from A' and G. Two hooks, Y and Z, analogous to A' and G, and designed to receive the other receiver, are simply for putting it into short circuit when but one receiver is being employed.

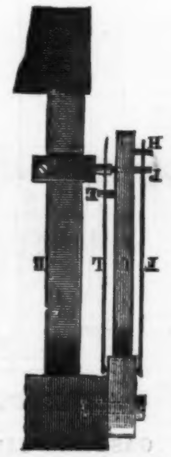


FIG. 36.

For cases where there would be no advantage in having one's own bell ring when he calls, the automatic commutator just described has been modified in such a way as to make it fulfill the same conditions as the one shown in Fig. 27.

This new arrangement will be seen in Fig. 36. Here the pin, H, is no longer metallic, but insulating. The springs, F F, communicate, and are connected with the

* Continued from SUPPLEMENT No. 501, page 8002.

line. Two new contacts have been arranged behind the piece, U. In a state of rest, these bear upon a metallic pin, E. The portion of the projection, P, that is opposite L L is surrounded by an insulating sleeve. The springs, L L, are connected with the bell on the

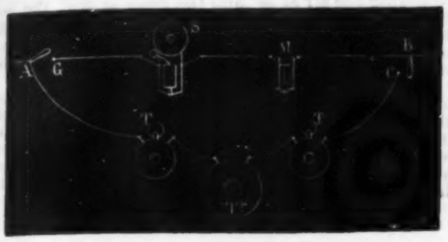


FIG. 37.

one hand and with the line on the other. In a word, the communications are exactly the same as in Fig. 27. Figs. 39 and 40 show the operation of an apparatus provided with the new commutator.

Finally, we shall cite the last form given, the magnetic

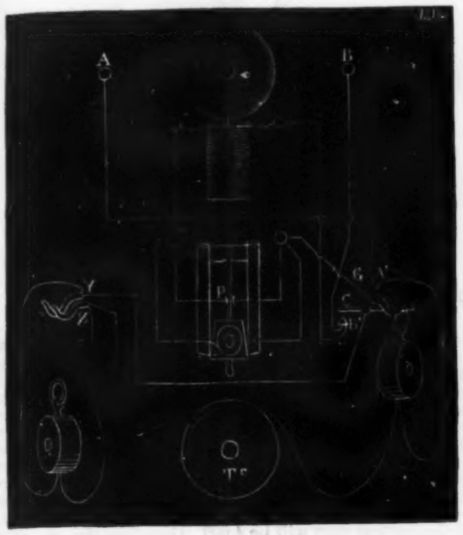


FIG. 38.

telephone apparatus, that is, the portable apparatus shown of actual size in Figs. 41 and 42. Here the parts have been greatly condensed. The bell, which has been given the form of a sort of box-cover, constitutes the

FIG. 39

back part of the apparatus, and the telephone, which serves both as transmitter and receiver, forms the anterior part. Finally, the call and bell are placed in the remaining space. This apparatus is designed for mili-

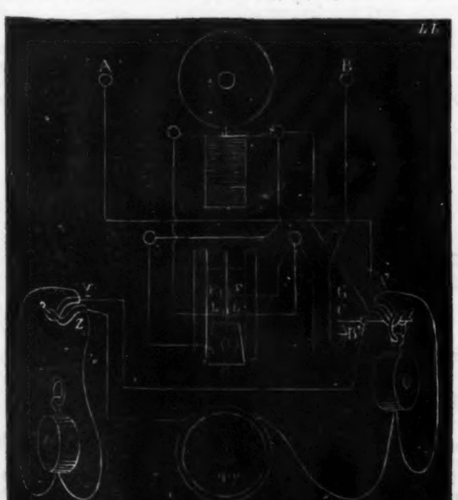


FIG. 40.

tary telephony. We must add, however, that this small apparatus will need a few more improvements before it reaches a truly practical form. The telephonist will have to carry but one of these little appa-

FIGS. 41 AND 42.—PORTABLE MAGNETIC TELEPHONES.

FIG. 43.—APPLICATION OF THE TELEPHONE TO MILITARY OPERATIONS.

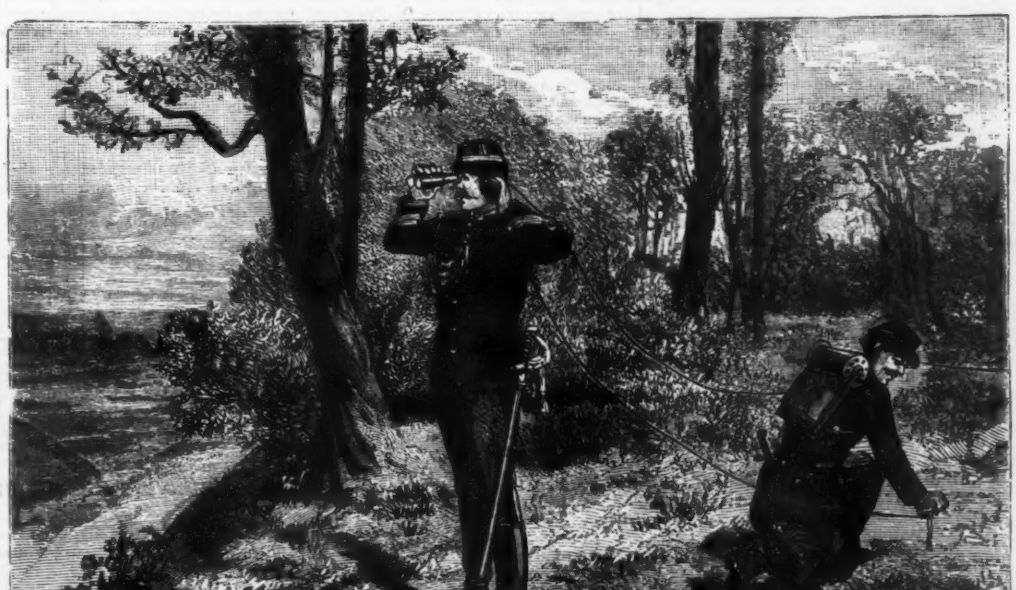


FIG. 44.—APPLICATION OF THE PORTABLE TELEPHONE.

ratus and the bobbin of wire to be unwound. He will be freed from the weight of a pile. At rest, the apparatus suspended by its ring stretches a spring which carries this ring, and which performs the role of the hook of the ordinary apparatus.

Figs. 43 and 44 show the applications of this apparatus. The first shows us an artillery officer in observation under a shelter during practice in firing. He gets the exact falling points of the projectiles shot at a mock battery that may be seen, and, by means of the telephone, transmits them to the officer who is in command of the school of practice—telling him how far the shots have fallen short of or gone beyond the mark, and how far to the right or left.

In the second engraving we perceive a staff officer reconnoitering. He has advanced to the edge of the woods that shields the troops, while a soldier following in his footsteps unwinds and lays a telephone line that keeps the observer in constant communication with his chief.—*La Lumiere Electrique.*

[Continued from Supplement, No. 501, page 8006.]

[Journal of the Society of Arts.]

ON THE CONVERSION OF HEAT INTO USEFUL WORK.*

By William Anderson, M.Inst.C.E.

LECTURE V.

At the conclusion of the last lecture, I explained how the waste of heat in furnaces, in which the work has to be done at a high temperature, is prevented by the Siemens regenerator.

I will illustrate this principle farther by a still more interesting case, connected with the blast furnace for smelting iron ore.

A modern blast furnace for smelting iron ores consists of a hollow tower with thick walls, hooped with iron, having the inside shaped principally in the form of two truncated cones, the upper cone having its smallest diameter at the top, or throat, of the furnace, and the lower one having its least diameter at the bottom, where it joins a smaller cylindrical part, or hearth, provided for holding the liquid iron. The top, or throat, of the furnace is fitted with a large iron hopper by means of which the fuel and ore are introduced. In all the best furnaces this hopper is closed by an iron cone, having its apex turned upward, and capable of being lowered sufficiently to allow any materials in the hopper to drop into the furnace. Some of the modern furnaces attain to immense proportions, viz., 90 feet high, and 29 feet diameter inside at the largest part, with a capacity of 33,400 cubic feet. Many furnaces are not more than 60 feet high, and are even lower in districts where the coke used is of a soft character, or where coal is employed.

By means of the hopper, the proper proportions of fuel, ironstone, and limestone are continually supplied, the furnace being always kept nearly full night and day. The blast of hot air is forced in by means of tuyeres introduced through the sides of the upper part of the hearth. The pressure varies greatly, being least when charcoal is used as the fuel, and greatest with hard coke or anthracite. The general pressure in this country is from 4 lb. to 6 lb. per square inch, but $10\frac{1}{4}$ lb. is being used in America, in certain works, where as much as 1,833 tons of iron per week are produced from a single furnace, with the aid of "Cowper stoves." The action in the furnace is as follows: The hot air, forced in at the hearth, enters immediately into intense combustion, with a corresponding quantity of carbon, thus producing carbonic acid gas and sufficient heat to melt the iron ore, which had been previously reduced in the upper part of the furnace, and also the limestone, which acts as a flux, so that both drop down into the hearth, the liquid iron sinking through the liquid slag formed of the limestone and refuse of the iron ore; the slag runs out continuously at a small hole at the side above the liquid iron, which is only tapped at intervals. The carbonic acid gas, in its upward course through the red-hot materials which are slowly making their way down, takes up another equivalent of carbon, thus becoming carbonic oxide which, at a red heat, reacts on the oxide of iron of the ore, and reduces it to a metallic sponge, the oxygen uniting with the carbon in the carbonic oxide, converting it again into carbonic acid, which, however, is again reduced by coming into contact with carbon from the fresh fuel.

The process goes on for a considerable portion of the height of the furnace, the temperature becoming lower and lower on account of the fresh cold materials continually added, until it gets too low for chemical reaction to proceed. The gases escaping ultimately are, therefore, chiefly carbonic oxide and the nitrogen of the air which was forced in at the hearth.

In olden times, these gases were allowed to escape freely at the top of the furnace, which was always open; and when using coal in the "Black Country," the gases burned with a bright flame, producing a conspicuous feature in the landscape.

After the introduction of hot blast, however, the escaping gases were collected and carried down, by means of pipes, to heat the air entering the bottom of the furnace. A marked economy of fuel, and an increase of yield, followed this grand improvement; but a limit to the temperature of the blast was soon reached from the want of some material to stand the intense heat of the air-heating stoves. Cast iron pipes in various forms, set in brick ovens, were used; the wear was very great, and the leakage from defective joints so serious that high pressure blast could not be employed, nor the temperature of melting lead, about 600°, exceeded.

Here Mr. E. A. Cowper stepped in, and applied the regenerative principle to blast-heating stoves. These have now assumed grand proportions, 60 feet high and 25 feet diameter.

The stoves are worked in pairs, one stove of a pair being heated by the combustion of the gases brought down from the furnace top, and the other imparting the heat previously acquired to the blast. Each stove consists of an air-tight wrought-iron cylindrical casing, lined with firebricks. Toward one side a flame flue is carried up, while all the rest of the cylinder is filled with firebrick, formed in short lengths, and built up so as to make a honeycomb arrangement with walls about two inches thick. Each cell is continuous from top to bottom, but stops short of both, so that there is a chamber at the top, into which the flame-flue opens, and one at the bottom connected with the chimney and the blast main. The action is as follows: The gases from the furnace are admitted by a suitable valve to the bottom of the flame-flue, and a supply of air, also controlled by a valve, is arranged to mix as intimately as possible with the gases. Complete and very intense combustion takes place in the flame-flue, and the highly heated products, having ascended to the top, pass down the honeycomb regenerator to the chamber in the bottom, and so through a suitable valve to the chimney. The heating of the stove goes on for several hours, until the full temperature has been attained to a sufficient depth in the regenerator; that is to say, to near the bottom. The gas, air, and chimney valves are then closed, the valve on the air main is

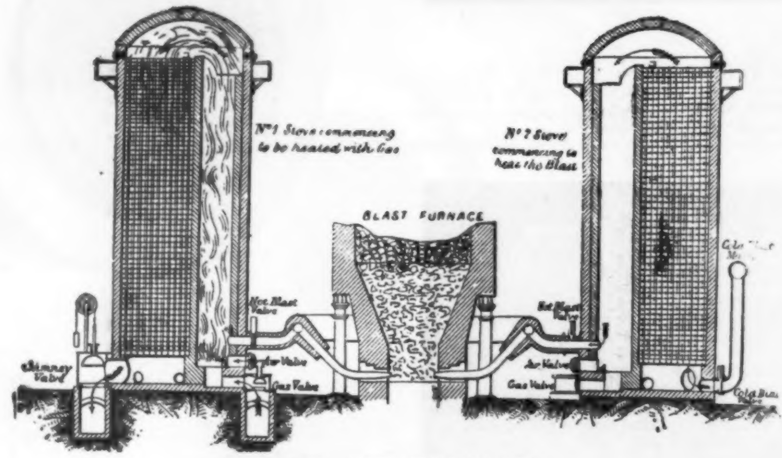


Fig. 30.—COWPER STOVES.

opened, and the cold air admitted into the chamber under the regenerator; the air rises through the colder part first, then becomes fully heated, and passes through the remainder of the regenerator without taking up more heat, and after reaching the top turns down the flame flue, and so passes through a valve to the tuyere, by which it is injected into the base of the furnace. As the stove works, the brickwork cools gradually from the bottom upward, the upper layers changing very little in temperature, and when, after several hours, the cold zone has rizen so high as to affect the temperature of the blast, the air is shut off, and the gas again turned on. In the mean time, the fellow stove has been acting in the reverse direction, so that one stove is always heating the blast, and the other is being heated by the gas. The effect of this ingenious and simple invention is, that the blast can be heated to 1,600°, and the gases cooled to from 250° to 350°, without leakage, and with scarcely any wear and tear.

I said that the blast furnace is a particularly interesting case; the reason is, because the products of combustion are endowed with energy, partly in the form of heat, and partly in the potential state of carbonic oxide gas; so that if this gas were allowed to escape, even in a comparatively cool condition, a great waste of heat would take place.

The work due to the energy of combustion in the bottom of the furnace is expended partly in heating the cold materials charged into the furnace, partly in decomposing the hot fuel, partly in decomposing the limestone, and partly in detaching the oxygen from the ore. These operations reduce the temperature of the gases, in a well conducted furnace, as low as 374°, so that, at first sight, no great loss occurs; but if we analyze the gases, we find that associated with 12·1 per cent. of carbonic acid and 59 per cent. of nitrogen are 26·1 per cent. of carbonic oxide and 2·51 per cent. of hydrogen. A reference to the table tells us that one pound of carbonic oxide burned to carbonic acid develops 4,326 units of heat; and one pound of hydrogen converted into vapor, 53,338 units, so that the combustion of the mixed gases will develop

$$CO\ 0{\cdot}261 \times 4{,}326 = 1{,}129 \text{ units.}$$
$$H\ 0{\cdot}0281 \times 53{,}338 = 1{,}499 \text{ units.}$$
$$\text{Total} \ldots\ldots\ldots 2{,}628 \text{ units.}$$

These reactions require 0·3738 lb. of oxygen for their completion, corresponding to 1·714 lb. of air. Supposing the gases to burn at the top of the furnace with the theoretical quantity of air only, the temperature would rise $\dfrac{2{,}628}{2{\cdot}714 \times 0{\cdot}238} = 4{,}068°$, so that by letting the gases escape, even cold, a very great loss would be experienced. It is possible, however, in consequence of the large proportion of neutral gases, amounting to 71 per cent., that a considerable excess of air is necessary to insure complete combustion of the carbonic oxide and hydrogen, especially as the burners in the stoves do not mix the gases very perfectly. If we suppose that twice the quantity of air is necessary, then the temperature of flame will only rise $\dfrac{2{,}628}{4{\cdot}428 \times 0{\cdot}238} = 2{,}494°$; and supposing the air at 50° and the gases at 400°, the mixture of air and gas entering the stove will be at 127°, then the temperature of the flame will be 2,621°, equal to 3,131° absolute, a temperature at which cast steel will melt.

Bearing in mind Carnot's law, that the efficiency of a heat engine depends only upon the range of temperature, and is quite independent of what takes place during the working, provided always that the fall of temperature is caused by the work done, and Berthelot's law that intermediate reactions do not affect the final thermal results, we can compare the efficiency of various furnaces if we only know the extreme temperatures. Unfortunately, we have no means of measuring the temperature of the blast furnace where the heat is most intense; we must estimate it, therefore, by supposing that the rise of temperature is that due to the combustion of coke with the minimum amount of air, that is, 4,588°; but this exceeds the limits we have set due to dissociation, which is 4,000° absolute; let us then assume that as the maximum. Take, first, the open-topped furnace, in which the gases are not utilized, but burn at 2,000°, blast at 800°; the absolute temperature of the hottest part will be 4,000°, therefore the efficiency will be—

$$\frac{4{,}000 - 2{,}460}{4{,}000} = 0{\cdot}38, \text{ or only 38 per cent.}$$

Next, take a blast furnace, using pipe stoves, from which the products of combustion go to the chimney at an ascertained temperature of 1,250°, or 1,710° absolute, and with the same temperature of blast as before, the efficiency is $= \dfrac{4{,}000° - 1{,}710°}{4{,}000} = 0{\cdot}57$, or 57 per cent., a gain of 19 per cent.; and, lastly, take the furnace with Cowper stoves, heating the blast to 1,600°, and allowing the product of combustion from the gases to escape to the chimney at 300°, we have the temperature of the furnace at 4,000° as before, but the smoke escapes from the stoves at only 760° absolute.

$$\text{The efficiency} = \frac{4{,}000° - 760°}{4{,}000} = 0{\cdot}81.$$

The Cowper stove, therefore, realizes a saving of 0·81 − 0·38 = 43 per cent. over the open-topped furnace, and 0·81 − 0·57 = 24 per cent. over the pipe-stove furnace. Mr. Cowper states that on the average of 100 furnaces, the saving in practice is 20 per cent. in fuel, which agrees fairly well with the estimate we have made, based upon the truth of the general principles which I have explained.

The work done by the energy of combustion is so intricate, and requires considerations so purely chemical, that I will not attempt to bring them before you. I will merely mention that the effect of the Cowper stoves on the blast furnace is to make from 10 to 20 per cent. more iron, with a saving of coke ranging from 4 to 5 cwt. per ton of iron made, an advantage due to the improved chemical action consequent upon the high temperature of the blast.

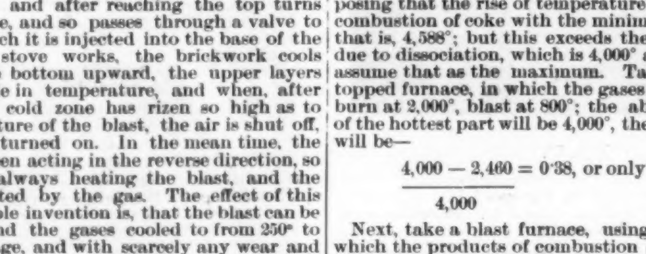


Fig. 31.—CURVE SHOWING PROBABLE PRESSURE IN BORE.

If it were possible to reduce the products of combustion in the stoves to the temperature of the atmosphere, say 50°, the duty would increase to 80 per cent., and beyond that it will be impossible to increase the economy of a furnace. Through the kindness of Mr. Cowper, I am enabled to show you a high temperature thermometer, such as is used by him in ascertaining the heat of the blast. It is, in principle, the same as the pyrometer described in my third lecture, but a ring of copper is used instead of a platinum ball, and the mercury thermometer in the water space is fitted with

* Lectures recently delivered before the Society of Arts, London.

a sliding scale, the zero of which can be set to the end of the column of mercury, wherever it may be. The scale is graduated by experiment, so that the temperature attained by the ring can be read off at once. The pyrometer was first described by Mr. Wilson, of the Bridgewater Works, St. Helens, in 1852. The instrument before you has been manufactured by Messrs. Siemens and Co., hence it is commonly, though erroneously, known as the Siemens pyrometer.

I am also indebted to Mr. Cowper for this working model of one of his stoves. A large Bunsen burner has been heating it for several hours, and yet the products escaping at the top are so cool that they are carried off by this paper chimney. I now remove the stove from its stand, and set it on a pad of clay. I close the top by means of a zinc plate luted down with clay and secured by a weight. I then turn on a blast of cold air from the top downward; the blast of air issues by this side opening near the bottom, and is so hot that it easily melts this strip of lead which I hold in the current, and sets fire to this twist of paper the moment I bring it within its influence.

The simplest machine in use for the conversion of heat into work is a gun. It is a single acting engine which completes its work in one stroke, and does not, like most engines, work in a continuous series of cycles. In the discharge of artillery many interesting considerations arise, and as I believe that the illustration of a particular case will fix itself better in your memories and be more intelligible, I will take the case of the new pattern 10 inch breech-loading rifled gun. This weapon weighs 27 tons, is 26 feet 8 inches long, and discharges a shot weighing 500 lb., impelled by the energy latent in 300 lb. of gunpowder, with a muzzle velocity of 2,100 feet per second, the shot at the same time receiving a rotatory motion of 84 revolutions per second.

From the experiments of Sir Frederick Abel and Captain Noble, we know that the maximum temperature of the explosion of pebble powder is 4,420° Fahr. absolute. The temperature of the gases issuing from the muzzle of the gun has not been measured, but it certainly attains to a bright red heat, which is about 2,160° absolute. The powder, therefore, works between the temperatures of 4,420° and 2,160°; the duty which we may expect will consequently be, according to Carnot's law,

$$\text{Duty} = \frac{4{,}420-2{,}160}{4{,}420} = 0{\cdot}5113,$$

that is to say, we must not expect to realize more than 51 per cent. of the heat developed in the combustion of powder.

From the authority already quoted, we learn that the explosion of a pound of powder develops 1,300 units of heat. The specific heat is given as 0·183 at constant volume, hence the total heat resident in exploded powder, at an atmospheric temperature of 50°, or 510° absolute, is:

$$(510° \times 0{\cdot}183) + 1{,}300 = 1{,}393{\cdot}3 \text{ units},$$

and of this we can only expect to realize

$$1{,}393{\cdot}3 \times 0{\cdot}5113 = 712{\cdot}41 \text{ units},$$

corresponding to $\dfrac{712{\cdot}41^{u} \times 772^{J}}{2{,}240 \text{ lb.}} = 245{\cdot}53$ foot tons of energy per pound of powder, so that the total charge of 300 lb. should be capable of producing work amounting to 73,658 foot tons.

The work done by the discharge of the gun must be classed under two heads:

I. Work external to the gun, the reaction of which causes recoil; and

II. Work self-contained in the gun, which produces no visible effect upon it.

To the first class belong:

1. The energy imparted to the shot in its forward motion.

2. The energy absorbed in the expulsion of the powder gases.

3. The work done in displacing the atmosphere by the ejection of the shot and powder gases.

To the second class belong:

4. The energy expended in producing rotation in the shot.

5. The work done in overcoming the friction of the gas check.

6. The work done in stretching the material of the gun, in setting up vibratory motions, and in compressing the shot and breech-block.

7. The friction of the powder gases against the bore of the gun.

8. The energy absorbed in heating the gun.

I will deal with these items in detail.

1. The muzzle velocity of the shot can be determined with great accuracy by experiment, and, in the particular gun we are considering, has been found to be 2,100 feet per second; consequently the energy imparted to

$$\text{Shot} = \frac{500 \text{ lb.} \times 2{,}100^2 \text{ ft.}}{64{\cdot}4 \times 2{,}240 \text{ lb.}} = 15{,}285 \text{ foot-tons.}$$

2. The combustion of gunpowder results in about 57 per cent. of very finely divided solid matter and 43 per cent. of permanent gases. That the solid matter *is* in a very fine state of subdivision may be inferred from the slowness with which powder smoke falls to the ground. When large guns are fired at sea, and heavy clouds of smoke are formed, they sail over the water for many miles, and remain visible for a long time, though fired within a few feet of the sea level; hence the particles must be very minute.

The condition within the bore of the gun is not indeed the same, because the smoke formed is the result of chemical action after the gases have left the gun; but the particles of solid matter in the bore are certainly not larger than those which form the smoke, and though they constitute 57 per cent. of the cloud, they do not sensibly alter its gaseous properties; and, therefore, the mixtures of solids and gases, forming the products of combustion of powder, may be treated, as far as its physical properties are concerned, as all gaseous, but of a higher specific gravity than the pure gases evolved. At the moment of the shot leaving the muzzle, it has been ascertained by experiment, though not in a trustworthy manner, that the gas pressure is about 3,875 tons, or 8,680 lb. per square inch; the volume of the bore of the gun is 16·72 cubic feet; hence the 300 lb. weight of powder gas occupying that volume must weigh 17·94 lb. per cubic foot; consequently, the pressure will be represented by a column of gas, of the above density,

$$= \frac{144 \text{ sq. in} \times 8{,}680 \text{ lb.}}{17{\cdot}94 \text{ lb.}} = 65{\cdot}013 \text{ feet high.}$$

When the muzzle of the gun is suddenly opened, the gases will begin to issue as from an orifice in the side of a vessel, with a velocity proportional to the height of the gaseous column $= 8{\cdot}05 \sqrt{65\,012} = 2{,}125$ feet per second, or very little more than that of the shot, which seems to indicate that the 10 inch gun cannot, with advantage, be increased in length without increasing the charge of powder. Supposing the whole body of gas to issue with the above velocity, then the energy expended will be $\dfrac{300 \text{ lb.} \times 2{,}125^2}{2{,}240 \text{ lb.} \times 64{\cdot}4 \text{ feet}} = 9{,}388$ foot-tons. But the gases being elastic, their whole body will not move at the same speed, so that the above calculation may be erroneous to a considerable extent. The limits between which the energy absorbed in the expulsion of the powder gases will vary may, I think, be determined by the following considerations: One pound of powder produces 4·485 cubic feet of gas at the freezing point, and under the pressure of one atmosphere. This volume would be increased to 4 651 cubic feet at a temperature of 50°, consequently 300 lb. of powder would yield 1,395 cubic feet of gas at atmospheric pressure and temperature. We must suppose that this gas will obey the laws applicable to all permanent gases; its specific weight is nearly three times that of air, hence the work done in heating at constant pressure will be less, the value of γ consequently is only 1·143 if the specific heat at constant volume is taken as 0·183. Suppose the gases violently compressed into the bore of the gun, measuring 16½ cubic feet, the pressure would arise according to the ordinates of an adiabatic curve, and we should have, finally,

$$p = \frac{14{\cdot}7}{2{,}240}\left(\frac{1{,}395}{16{\cdot}72}\right)^{1{\cdot}143} = 1{\cdot}03 \text{ tons}$$

pressure per square inch in the gun, and a temperature of t: $510° \left(\dfrac{1{,}395}{16{\cdot}72}\right)^{1{\cdot}143} = 960°$ absolute.

The work done in compressing the gas would be:

$$w = \frac{1{,}395 \text{ c. ft.} \times 2{,}117 \text{ lb.}}{0{\cdot}143 = 2{,}240} \left\{ 1 - \left(\frac{1{,}395}{16{\cdot}72}\right)^{0{\cdot}143} \right\} = 8{,}131$$

foot tons. Now, the compressed gas, if suffered to expand suddenly, would do the same work, and the reaction on the gun, according to Newton's third law, would be the same. This, I think, would mark the superior limit of work done in expelling the gases. If, on the other hand, the gases were compressed slowly into the gun without change of temperature, the pressure would rise along the ordinates of an isothermal curve, and would only reach 0·55 ton per square inch pressure, and the work done would be 5,833 foot tons. This would fix the lower limit. It is certain that the gases, at the moment when the shot leaves the muzzle, have a much higher temperature than 960° absolute. The work done in the bore of the gun, we shall see presently; amounts to about 28,931 foot tons, corresponding to 83,900 units of heat, which must disappear, as heat, from the powder gases; the fall of temperature, consequently, will be

$$t = \frac{83{,}900 \text{ lb.}}{300 \text{ lb.} \times 0{\cdot}183} = 1{,}528°,$$

which, deducted from the temperature—4,420°—due to energy of chemical action in the combustion of the powder, leaves 2,892° absolute as a possible temperature at the moment of the shot leaving the gun, if no allowance is made for a farther fall caused by loss of heat expended in warming the gun and shot. This temperature is only 732° higher than that which I have assumed.

The usual method adopted in artillery text-books of estimating the energy expended in expelling the powder gases, when it is not overlooked altogether, is to consider that from one-half to the whole weight of powder is expelled at the same velocity as the shot, but this is mere assumption, without any rational foundation, and takes no account either of the proportions of the gun or the pressure in the bore, the latter being a function of the nature of the powder and mode of ignition. Upon the whole, I am inclined to think that the method which I indicated to the Ordnance Committee last June is fairly correct, namely, that the energy expended in the expulsion of the powder gases should be taken on the supposition that they are blown out of the gun at the velocity corresponding to their ascertained pressure at the moment when the shot leaves the muzzle. The formula is:

$$\text{Velocity of gases} = 4{,}544 \sqrt{\frac{\left(\begin{array}{c}\text{Pressure in tons}\\ \text{per square inch}\end{array}\right) \times \left(\begin{array}{c}\text{Volume of bore}\\ \text{in cubic feet}\end{array}\right)}{\text{Weight of powder in pounds}}}$$

When the weight and velocity are known, the energy is, of course, easily calculated. The terminal pressure is difficult to arrive at. I do not believe that any gauges yet invented give trustworthy results, because the time during which the record has to be taken is so short. It may seem strange that the pressure curve in the bore of a gun cannot be determined by direct calculation, but the reason is, that the powder continues to burn and evolve gas during the greater part of the time that the shot is traveling along, and, as the rate of evolution is unknown, of course no formula can be constructed on purely theoretical considerations.

3. The displacement of the atmosphere. I shall, later on, allude to the rapidity with which the gases are expelled from the gun. I will merely state now, that the action is extremely rapid, and that the reaction to the effort of parting the air must be a pressure on the base of the bore.

We have assumed a temperature of 2,160° for the gases at the moment of the shot leaving the muzzle. The pressure due to gases at 50°, suddenly compressed into the gun, we found to be 1·03 tons per square inch, and the temperature 960·1°. The pressure corresponding to 2,160° would be equal to:

$$\frac{1{\cdot}03 \text{ tons} \times 2{,}160°}{960{\cdot}1} = 2{\cdot}32 \text{ tons}$$

per square inch, or 5,194 lb. In expanding suddenly, the temperature would fall to

$$t' = 2{,}160° \left(\frac{14{\cdot}7 \text{ lb.}}{5{,}194 \text{ lb.}}\right)^{0{\cdot}125} = 1{\cdot}037°,$$

and the volume would become

$$\frac{1{,}395 \text{ c. ft.} \times 1{,}037°}{510°} = 2{,}837{\cdot}4 \text{ c. ft.}$$

Deducting 5 cubic feet for the volume of the solid powder, we have 2,832·4 cubic feet of air displaced. The work of doing this will be:

$$W = \frac{2{,}832{\cdot}4 \text{ c. ft.} \times 2{,}117 \text{ lb.}}{2{,}240 \text{ lb.}} = 2{,}677 \text{ foot-tons.}$$

4. The rifling of the gun causes the shot to spin on its longitudinal axis as it traverses the bore. The angle of the rifling of the muzzle is such that the shot makes one revolution in thirty calibers, that is, in 300 inches, or 25 feet; hence, dividing the muzzle velocity by 25, we get the revolution per second to be 84. Now the diameter of the circle of gyration of a cylinder 10 inches in diameter is 7·072 inches, and its circumference 1·851 feet; therefore, at 84 revolutions per second, the velocity at the circle of gyration will be 1·851 feet × 84 = 155·52 feet per second, and the energy

$$\frac{500 \text{ lb.} \times 155{\cdot}52^2}{2{,}240 \text{ lb.} \times 64{\cdot}4} = 83{\cdot}82 \text{ foot-tons.}$$

The reaction to this motion is twofold. First, the resistance of friction of the rifling balanced by the pressure of the gases, and therefore a self-contained strain; and secondly, a tangential pressure, tending to rotate the shot, balanced by an effort to turn the gun in the opposite direction. Neither of these motions has any effect on the recoil.

5. The friction of the gas check is a matter of pure estimate, especially with the ring checks now in use. I assume a mean pressure of powder gases of 12 tons per square inch, and suppose a copper band of ⅛ inch effective depth pressed against the surface of the bore with that pressure. Taking the coefficient of friction at 0·14, we have a surface of 15·7 square inches in contact under a pressure of 12 tons, and a space passed over of 22·5 feet; the work done will therefore be

$$15{\cdot}7 \text{ sq. in.} \times 12t \times 0{\cdot}14 \times 22{\cdot}5' = 593{\cdot}5 \text{ foot-tons.}$$

The force assumed is equivalent to a pressure of 0·35 tons per square inch on the base of the shot, or 0·87 tons per lineal inch of circumference. I believe that actual experiment has shown that to force a shot slowly through the bore requires a pressure of half ton per square inch in the smaller guns, but necessarily this is a very variable and uncertain quantity.

6. The energy expended in stretching the gun and compressing the shot and breech block is very difficult to estimate. The 10 inch gun is supposed to have a factor of safety of about four, so we may assume that the metal is impressed with a strain of six tons per square inch. The mean volume of the gun, that is, the volume to the center of the metal, is about 49·45 cubic feet, and I estimate that this will stretch to 49·696 cubic feet, absorbing 0·246 c. ft. × 0·144 sq. in. × 6t = 212·5 foot-tons. The strain, however, does not come on uniformly, but follows the shot along the bore, giving rise to a wave-like motion which must produce cross strains difficult to estimate, but very serious, especially where guns are built of rings suddenly changing very much in diameter. There are, besides, other sources of vibration. The powder burns unequally, and most probably the gases evolved are traversed by pulses which must be communicated to the metal which confines them. In the modern long light guns, the weight of the shot, as it travels along the bore, sensibly depresses the muzzle, and this movement is aggravated by the powder heating the upper half of the gun more quickly, and to a greater extent, than the lower. The moment the shot leaves the muzzle, the barrel springs back, and vibration, which, I understand, is actually visible to the eye, is set up. Again, the powder gases, as they rush out, rub so hard against the sides of the bore that they actually, in places, erode the metal, and must produce longitudinal pulses similar to those you have seen induced by friction in the brass and glass tubes of the apparatus for demonstrating the existence of molecular motion producing sound.

The simultaneous occurrence of vibrations of different wave length and intensity in a gun implies that there will be interference, that is to say, as in the case of waves of sound or undulations in water, waves may coincide and produce a more intense effect, or, on the other hand, they may neutralize each other wholly or in part. It is well known that guns of different caliber and different metal have each their peculiar ring, which is audible through the main sound of the discharge, like overtones on a fundamental note in music.

Messrs. Chernoff and Beck-Gerhard, of St. Petersburg, have noticed and described the manner in which sudden strains, such as those caused by punching, shearing, or hammering, are propagated through steel plates. By operating on polished plates, they have been able to render the waves of strain not only

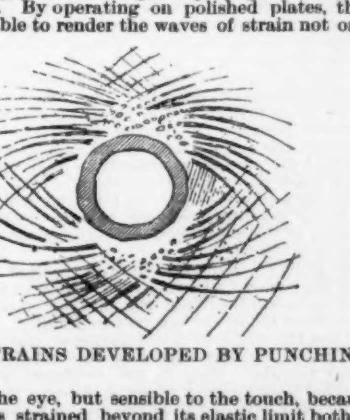


FIG. 32.—STRAINS DEVELOPED BY PUNCHING.

visible to the eye, but sensible to the touch, because the metal is strained beyond its elastic limit both in tension and compression, and consequently remains impressed with wave-like hollows and ridges. Mr. Chernoff suggests that similar abnormal lines of strain

may arise in the metal of guns, and lead to the otherwise unaccountable failures, especially of inner tubes, which so often take place.

7. The friction of the powder gases against the sides of the bore it is impossible to calculate with even an approach to accuracy, because we cannot tell whether the laws and coefficients applicable to ordinary temperatures and pressures will apply under the circumstances. Yet supposing that they do, and that the hot powder gases will behave like air, we may take the mean pressure we have already assumed of 12 tons per square inch, and an average speed of 1,000 feet per second through a bore 26 feet long, and applying the ordinary formula for the friction of air in pipes, we obtain a resistance of 690 foot tons. This may seem an altogether exaggerated estimate, but it must be remembered that the friction of gases increases as their pressure and as the square of their velocity, and that we are dealing with very high figures in both respects. It is also well to note that the friction of the gases close to the powder chamber, where the temperature and pressure are greatest, and where they expand after the temporary contraction caused by passing the shoulder of the chamber, and therefore strike with increased energy against the bore, is sufficient to score and rasp away the metal, and become by that means the chief agent in the deterioration of guns.

Dr. BALANCE SHEET OF TEN INCH GUN. *Cr.*

	Foot tons.			Foot tons.	Foot tons.	Per cent.	Per cent.
			I. EXTERNAL WORK.				
Available energy of 300 lb. of powder working between 4,420° and 2,160° absolute......	73,658	1	Energy of shot......	15,285			
		2	Energy of expelled gases......	9,388			
		3	Energy in displacing air......	2,677	27,350	37	94
			II. INTERNAL WORK.				
		4	Energy of rotation...	84			
		5	Energy in friction of gas checks......	594			
		6	Energy in stretching gun......	213			
		7	Energy in friction of gases......	690	1,581	2	6
			Energy in heat imparted to gun and shot = 17·9°......	44,727	44,727	61	
	73,658				73,658	100	100

Collecting all the items we have been discussing into the form of a balance sheet, we find that the discharge of the 10 inch gun performs 27,350 foot tons of external work and 1,581 foot tons of internal work. The available energy of the powder is 73,658 foot tons; hence there remains a balance unaccounted for on the credit side of 44,727 foot tons, which must have been chiefly expended in communicating to the metal of the gun the molecular motion which becomes apparent in the form of heat. This energy represents

$$\frac{44{,}727 \text{ foot tons} \times 2{,}440 \text{ lb.}}{772J} = 129{,}780 \text{ units.}$$

The gun and shot weigh 60,980 lb., and being of steel have a specific heat of 0·119, and therefore the rise of temperature of the gun from each discharge may be expected to be not more than

$$\frac{129{,}780\ u}{60{,}980 \text{ lb.} \times 0{\cdot}119} = 17{\cdot}9°.$$

This temperature will be very unequally distributed, and very quickly dissipated by radiation and conduction from the large surface of the gun.

Referring again to the balance sheet, we have estimated that the external work done in the discharge amounts of 27,350 foot tons, composed of three items, one of which, the energy necessary to expel the powder gases, is uncertain. The work being external, there must be the same amount of work in the recoil, because, according to the third law of motion, to every action there must be an equal and opposite reaction, and, therefore, the quantity of motion must be the same. The pressure producing recoil lasts only so long as the shot and power gases are being expelled from the gun, and consequently the time during which the maximum velocity of recoil is reached must be the same as the time consumed in the discharge, for acceleration ceases the moment the accelerating force ceases to act. Recoil, however, does not become visible simultaneously with the discharge, because a certain interval of time is necessary to transmit the pressure against the base of the bore of the gun to its carriage, so as to cause the latter to move. The gun stretches longitudinally, the trunnions compress the metal of their bearings, the material of the carriage stretches, and hence an appreciable delay occurs before visible motion begins, but is made up for by the persistence of the motion for an equal time after the discharge, because the reaction to the stretching of the system keeps up the acceleration. I have witnessed an interesting illustration of this fact in the case of the short 6·6 inch muzzle loading gun, mounted on a Moncrieff hydro-pneumatic carriage. The muzzle of the gun, when in the firing position, happening to be close to the concrete parapet, the powder gases, the instant the shot left the muzzle, flashed out as a disk of fire, and marked the parapet as sharply as if it had been done with black paint, and the margin of the discoloration next the gun was exactly in line with the muzzle when in firing position, proving thereby that no sensible motion of the whole gun has commenced till after the shot had left the bore.

In addition, although the gun recoiled instantly below the parapet, starting into motion at the rate of 22 feet per second, so that the muzzle of the gun must have been below the parapet in about $\frac{1}{5}$ of a second, yet not the slightest discoloration of the concrete was observable on the inside of the parapet, even after many rounds. This is the evidence which I have alluded to in support of my statement that the gases are wholly expelled from the gun in a very short space of time, and must exert a corresponding serious effect on the gun.

But not only must the accelerated motion of recoil take place in the same time as that occupied by the discharge, but because, according to Newton, velocity is proportional to the impressed force, the rate of acceleration of the shot and gases as they move along the bore at each instant must have its counterpart in the motion of recoil; hence the curve of velocities of recoil, could we construct one, would correspond to that for the velocities in the bore, but on a reduced scale. Because of the quantity of motion in the discharge and recoil being equal, and of the weight of the gun and its carriage being much greater than that of the spot and gases, the motion of the former will be so much slower than that of the latter, and therefore more easily registered. But how are we to obtain a faithful picture of the motion of recoil? The answer is, by means of a beautiful instrument invented by Colonel Sebert, of the French artillery.

This apparatus consists of a solid pedestal, secured to the ground beside the gun carriage. A tuning fork is fixed to the pedestal, and kept in vibration by means of a galvanic current. To one prong of the fork is attached a style or tracer, so arranged that it will scratch a wavy line upon a piece of blackened metal, one end of which is attached to the carriage, which, in recoiling, draws the strip along under the tracer. The tuning fork is adjusted to make 500 complete vibrations per second; this corresponds very nearly to the middle C of the musical scale. If a center line is drawn through the undulations, each complete beat will cut the line twice, so that each intersection will measure the $\frac{1}{1000}$ part of a second, and the pitch of each half wave will be the distance passed through in that minute fraction of time. The diagram traced will, therefore, give all the information which we require, namely, the total time of the accelerated motion of recoil, which will be up to the point where the waves attain their maximum pitch, the maximum velocity of recoil, and the rate at which the recoil is accelerated throughout, so that, knowing the weight of the gun and its carriage, we can determine the energy at any point, and, as I have already stated, this must be the counterpart of what takes place in the bore. A special instrument, provided with micrometers and a magnifying glass, is used for measuring the pitch, the amplitude of the vibrations, and the angle at which the wave line cuts the center line.

I have here an apparatus which will illustrate Sebert's instrument. Over the pulley secured to this

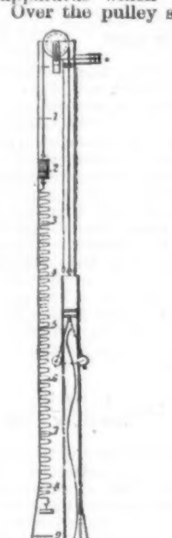


FIG. 33.

tall stand is passed a cord, to one end of which is attached a lath covered with a strip of paper, and to the other end is hung a weight, so adjusted as to give a moderate speed to the lath. As I showed you in my first lecture, the lath will move with uniformly accelerated velocity. In front of the lath hangs a pendulum, which makes a double swing in one second. Attached to its rod, near the point of suspension, is a pencil which presses on the paper. I first allow the lath to rise, while the pendulum is stationary; the pencil traces a straight center line. I draw down the lath, and set the pendulum swinging; the pencil traces a short arc. I now release the lath, which moves upward, and the pencil traces a wavy line, which intersects the center line previously traced. Each intersection defines the space passed through in half a second, and when we measure the total lengths cut off in 1, 2, 3, 4, half seconds, we find them to increase in the ratio of 1, 4, 9, and 16, which we know to be the rate of increment proper to a continuously acting force, such as gravity. On the diagram I have drawn this waveline. Hence, suppose the Sebert machine were to trace one like it, we should know at once that the pressure of gases in the bore of the gun must also have been uniform.

I now balance the weight of the lath exactly, and attach a spiral spring to the cord by which it was raised. In pulling down the lath I bring the spring into tension. I start the pendulum, and let go the lath; a curve is traced which represents velocities produced by a uniformly decreasing accelerating force, such as a spring. I have represented this also on a diagram, and were the Sebert apparatus to trace such a curve, we should know that the pressure in the bore was uniformly decreasing.

In all cases, supposing the carriage to recoil down an incline which would exactly compensate for friction, the curve, whatever its nature might have been during acceleration, would terminate in waves of equal pitch, corresponding to the maximum velocity attained, because, according to the first law of motion, the carriage would continue to move at a uniform velocity so soon as the impelling force ceased to act. The proper way, therefore, to measure the recoil is to mount the gun on a well made carriage, placed on an evenly laid line, which would, for the first two or three feet, fall in the direction of recoil at an incline corresponding to the friction of the carriage, and, after that, rise at any convenient rate sufficient to take up the energy imparted. It is hardly necessary to add that the work done in arresting the recoil will be equal to the work done in obtaining its maximum velocity, and also to the external work of the discharge, so that the determination of the second portion of the recoil will serve to check the first. As far as I know, up to the present, these two distinct parts of the recoil have been mixed up together, and no deductions as to the rate of work in the bore have been made from either of them. When the wave line has been obtained, it is easy to calculate the velocity at each intersection with the center line. The motion there is compounded of the maximum velocity of the tuning fork and the velocity of recoil. If a tangent be drawn to the wave line at the intersection with the center line, then the tangent of the angle made with the center line will be represented by the velocity of the fork divided by the velocity of recoil.

The amplitude of the fork's vibrations is constant throughout, and may be measured on the diagram; the maximum velocity, which occurs when the stile crosses the center line,

$$\text{is} = \frac{\pi \times \text{amplitude of vibration}}{\text{time of complete vibration}} = v$$

$$\text{velocity of recoil} = \frac{v}{\tan.\ a}$$

Suppose the amplitude $\frac{1}{100}$ of a foot and the number of vibrations 500 per second, maximum velocity

$$= \frac{3{\cdot}1416 \times 0\ 01 \times 500}{1} = 15{\cdot}7'.$$

Suppose the curve crosses the center line at an angle of $31\frac{1}{2}°$, then the speed of recoil will be $= \frac{15{\cdot}7'}{\tan.\ 31\frac{1}{2}} = 25{\cdot}62$ feet per second. The numerator will be a constant for each instrument.

The investigations which I have gone into are intended to lead up to the determination of the pressure of the powder gases in the bore of a gun. These pressures are up to the present unknown, except so far as they have been determined by the unsatisfactory agency of crusher gauges.

Referring to the balance-sheet, you will observe that the external work of the discharge forms nearly 37 per cent. of the whole work of the powder, and the internal work only 2 per cent., or, of the total mechanical work, the external is 94 per cent., while the internal is only 6 per cent., so that any error in estimating the several items of the latter will not sensibly affect the inferences to be drawn from the observations on the first portion of recoil. In the external work, also, the only uncertain item is the energy absorbed in the expulsion of the powder gases, hence, if, by means of the Sebert apparatus, we can determine the total external work, we can also determine exactly the uncertain item in our balance sheet.

The total mechanical work is equal to 28,931 foot-tons, and suppose that this were performed at a uniform rate throughout the stroke of 22 feet, we should have an average push of $\frac{28{,}931 \text{ foot-tons}}{22 \text{ ft.}} = 1{,}318$ tons; dividing this by the area of the base of the shot, 78·54 sq. in. gives an average pressure to the powder gases of 16·78 tons per square inch. The maximum pressure attained by the gases at the commencement of the discharge is believed to be about 18 tons per square inch, though I have reason to think that it must be considerably higher, and the lowest limit, calculating on the assumption that the temperature is 1,700°, about 2·32 tons; so that an empirical curve may be traced, which between those limits would include an area equal to the work done. If, however, the first part of recoil can be pictured by means of the Sebert velocimeter, and a curve of velocities obtained, it does not matter how irregular the curve may be, the pressures in the gun can be calculated in the following manner. The fact that the velocity of recoil is increasing implies that an impressed force is acting; hence, selecting two points in the recoil at a short measured distance from each other, ascertain by measuring the curve the velocities at the two points, let them be V_1 and V. The energy latent in the higher velocity will be $\frac{W}{2g}V_1^2$, and the lower $\frac{W}{2g}V^2$, the difference $\frac{W}{2g}(V_1^2 - V^2)$ must have been due to a pressure acting through the space S between the points $= P\ S$, hence the pressure—

$$P = \frac{W}{2gS}(V_1^2 - V^2).$$

As we know all the terms of this equation, the pressure P on the carriage will be known, and that will also be the pressure on the base of the bore at the corresponding period of discharge. If we divide this by the area of the bore, the pressure per square inch follows at once. In this way a curve of pressures in the bore may be accurately arrived at.

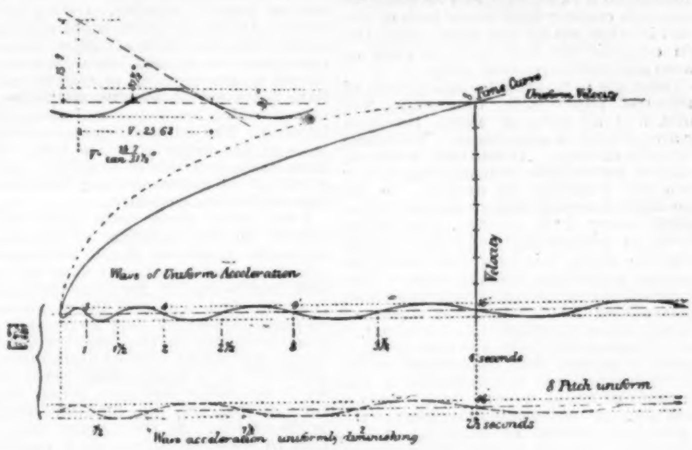
In addition to the tuning fork, the Sebert machine has styles fixed to the armatures of electro-magnets, the attractions of which, so long as the current is passing, keep the styles immovable; consequently, when the gun recoils, the styles trace a straight line close beside the wavy line of the turning fork. The wires from the electro-magnets are, however, carried across the line of fire, one just in front of the muzzle, a shot length off, and a pair through the ordinary velocity screens. As soon as the shot breaks the wires, the armatures leave their magnets, and their styles make a kink in the line they trace. The relative positions of these kinks, as to time and space, are defined by the undulations of the line traced beside them by the tuning fork. In this way the exact moment when the shot leaves the gun is ascertained. If the wave line has reached its maximum pitch before the shot leaves, then the gun is too long; if, on the other hand, acceleration of motion is still going on, then the gun is too short to absorb all the energy of the powder.

We can make an approximation to the recoil on the assumption that the pressure in the bore throughout

the discharge is constant, that the powder gases and shot are expelled at the same velocity, that the space passed through in the bore is 22 feet, and that the gun carriage weighs 5 tons, so that gun and carriage together weigh 32 tons. The powder and shot together weigh 800 lb., or 0·357 ton; we assume that they are expelled at a speed of 2,100 feet per second. Then, because of the equality of the quantity of motion, the maximum velocity of recoil will be $= \frac{2,100 \text{ ft.} \times 0·35 \text{ ton}}{32 \text{ tons}}$

$=23·42$ feet per second. The time of discharge, which will also be the time of the acceleration of recoil, $= \frac{2S}{V}$

$= \frac{44'}{2,100'} = 0·02095$ second.



FIGS. 34 AND 35.

The space passed through during the accelerated motion of recoil will be $= \frac{1}{2} tv = \frac{0·02095 \text{ sec.} \times 23·42 \text{ feet}}{2}$

$= 0·245$ foot, or nearly 3 inches.

The rate of acceleration during recoil $= \frac{V^2}{2S} = \frac{22·42^2}{2 \times 0·245'}$

$= 1,118$ feet per second, corresponding to the value of g in gravity; hence the accelerating force will be

$$\frac{32 \text{ tons} \times 1,118 \text{ feet}}{32·2 \text{ feet}} = 1,111 \text{ tons.}$$

The rate of acceleration in the bore of the gun

$= \frac{2,100^2}{2 \times 22} = 100,230$ feet per second, and the accelerating force

$$= \frac{0·357 \text{ ton} - 100,230 \text{ feet}}{32·2} = 1,111 \text{ tons;}$$

that is to say, the pressure on the breech, block, and against the carriage is the same, and equal to 1,111 tons, which, divided by 78·54 square inches, the area of the bore, gives 14·14 tons per square inch as the average pressure of the powder gases.

The energy of recoil

$$= \frac{32t \times 23·42^2}{64·4} = 272·7 \text{ foot-tons,}$$

which figure is also arrived at by multiplying the accelerating force of 1,111 tons by the space it works over $=0·245$ foot.

Suppose the carriage, as soon as the maximum speed of recoil has been attained, is made to run up an incline of 1 in 10, it would rise $\frac{1}{10}$ of a foot for every foot of recoil, and would do 3·2 foot tons of work. The resistance of friction would be about 8 lb. to the ton weight of gun and carriage

$$= \frac{32t \times 8 \text{ lb.}}{2,240} = 0·144 \text{ ton per foot,}$$

so that the total resistance would be 3·344 foot-tons per foot of recoil, and, therefore, the gun will come to rest in

$$\frac{272·7 \text{ foot-tons}}{3·344 \text{ foot-tons}} = 81·56 \text{ feet.}$$

It is very improbable, however, that the pressure in the bore can ever be uniform. Such an assumption is an extreme one, but we may take another extreme view, and suppose that the powder gases act like a spiral spring, the tension of which varies as the distance through which it is compressed. Under such circumstances, the velocity of recoil will vary as the square root of the difference between the square of the full compression of the spring and the square of the compression up to the point where the velocity is to be determined.

If P = pressure required to compress a spring one foot, S = full range of compression, S_1 range of compression at any other point, W weight moved, and V the desired velocity, the tension of the spring compressed to a distance S=PS, and its potential energy will be $=PS \times \frac{S}{2} = \frac{PS^2}{2}$. The kinetic energy would be $\frac{WV^2}{2g}$, and that must be equal to the potential—

$$\therefore \frac{PS^2}{2} = \frac{WV^2}{2g} \therefore P = \frac{WV^2}{gS^2}.$$

At any other point, S_1 feet compression, the energy is the total energy due to the compression S less that due to S_1

$$= \frac{PS^2}{2} - \frac{PS_1^2}{2} = \frac{P}{2}(S^2 - S_1^2) = \frac{WV^2}{2g}$$

$$V^2 = \frac{Pg(S^2 - S_1^2)}{W}$$

an $V = \sqrt{\frac{P \times g}{W}} \times \sqrt{S^2 - S_1^2} = a \sqrt{S^2 - S_1^2}$

I have calculated the curves of velocities which will produce a speed of recoil of 24 feet per second, in one-quarter of a foot, and have drawn them on the diagram (Fig. 36). The ordinates in curve No. 1 give the velocities due to a uniform pressure. You observe that the curve cuts the line of uniform velocity of 24 feet per second at an angle which indicates that the pressure must cease suddenly when the desired velocity is attained. Curve No. 3 gives the velocities, supposing the force to be of the nature of a spring, and you notice that the line of uniform velocity is a tangent to it, which indicates that the accelerating force ceases to act gradually, and, when the full velocity is attained, acts no longer.

The true velocities lie between these two, and I have interpolated curve No. 2, which will probably not be far from the mark. This curve has no known equation, but I have taken out the accelerating force in six places by the method already described, and so obtained a curve of pressure acting against the carriage, that is, against the bottom of the bore of the gun. Dividing this by the area of the bore, I obtain the pressure per square inch, and by changing the scale of the diagram, so as to make the base line represent the length of the chase, I get a curve of the powder pressure along the whole bore. The maximum pressure comes out about 20½ tons per inch, the minimum 2¾ tons, and the mean pressure 14·87. The area of the figure bounded by the curve of pressures will give the external work done; the figure is, in fact, an indicator diagram of the gun, but is still incomplete, for we must add seven per cent. to the pressures, amounting to nearly one ton per square inch, to represent the internal work, which does not affect the recoil. I have added this as a constant pressure throughout, though it may not be so, but, as you see on the diagram, the amount is small, and will not much affect the accuracy of the result, in what manner soever the pressure may really vary.

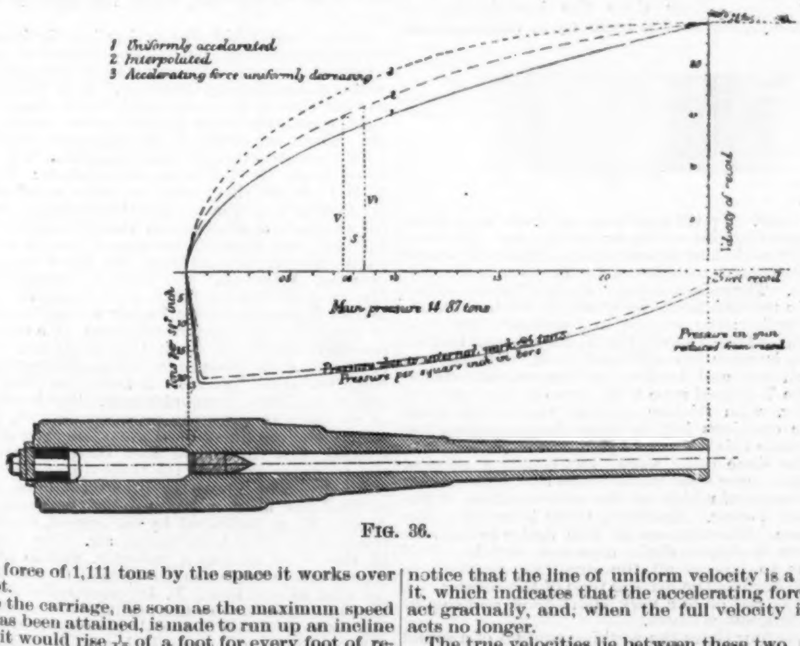


FIG. 36.

I have said that the indications of the crusher gauges, upon which so much reliance is placed, are untrustworthy; my reason for thinking so is because time is an element in the complete action of a shortening or extending movement in a metal cylinder; hence, in order that the indications given by compression may be comparable, the time during which the forces act must be either long enough to allow the whole effect to take place, or, at any rate, the same in all the experiments. Now, the compression of the little copper cylinders of the crusher gauges takes place in very short and very unequal times. The gauge in the breech is much longer exposed to the actions of pressure than in the muzzle, yet the change of length is compared uniformly with pressures slowly applied, and, therefore, the indications of the gauges are sure to be too low. I am confirmed in this view by the extraordinary coincidence between the pressures indicated by crusher gauges and those derived by calculation from increments in the velocity of shot as it traverses the bore. This velocity has been ascertained by Captain Noble by means of an instrument called a chronograph, which registers the time of the shot passing certain points in the chase. We have already seen how, from a curve of velocities, the pressure can be calculated; it is found that the crusher gauges indicate the pressures due to the accelerated motion of the shot only; hence, either their indications are erroneous, or else we must conclude that the powder gases have no weight, that there is no atmosphere to be displace, no friction of gas check or gases, and no work in producing rotation. This error is by no means a trifling one, for you will see by the balance sheet that the items I have just mentioned form over 40 per cent. of the whole mechanical work done.

Hydro-pneumatic carriages for disappearing guns furnish a very good means of measuring the intensity of recoil, because it is taken up chiefly by the compression of air. In the carriage for the 6·6 inch gun already alluded to, the calculations for the necessary air pressures were made upon the system laid before you in this lecture; the result of the trials at Shoeburyness indicates that the calculated recoil was realized within two or three per cent., demonstrating that my estimates of the force of recoil are not very far from the truth.

DRIVING BELTS.*

By MR. JOHN TULLIS, Glasgow.

WHEN coming before this convention the first thought that struck me was, "Can a man trained to the tanning, currying, and belt-making buisness be mechanical enough to make himself understood by practical millers and engineers?" Then, upon second consideration, I came to the conclusion that practical men would understand my shortcomings best and help very much to make my rough places plain. Therefore, I venture to say that a modern flour mill is now one connected machine, so much so that from the time the wheat is subjected to the first operation, it must travel onward from one grade to another until it is ready for the market. A single hitch of half an hour with one machine or one belt will disarrange the entire mill. A flooding will occur here and a scarcity there, upsetting the calculations of those millers whose delight is to see a continuous flow of the whitest and finest of flour, coming in such steady volume that from week to week they can tell almost to a bag how much they can manufacture. To the miller, therefore, the best of belting is a very important consideration, and little hints regarding the preserving of it may be of some use. All users of motive power are anxious to have the best, the simplest, and the least troublesome system of transmitting that power, and at as reasonable an outlay as possible. The question for consideration is, "Whether belts or ropes are the best and cheapest method?" Both of the systems have their admirers and advocates, and both have proved worthy of much patronage. First cost is often quoted when comparing ropes and belts. There is no doubt but that main belts are much more expensive than driving ropes of cotton or hemp. But we must also look at the first cost of rope pulleys, and compare them with the price of belt pulleys. When these values are considered, I believe the belt-driven mill will be started for very little more money than a rope-driven mill. If the speeds, diameters, and widths are properly calculated—giving 1 in. of width of belt, traveling at 500 ft. per minute, 1 horse power to transmit—the result will be eminently satisfactory. Well made properly stretched leather belts will run as straight as a line, last for thirty years, and be good for cutting up into smaller sizes after that. A mill engineered after this fashion has a long and comfortable life before it.

Main Driving Belts.—The belt is a soft and most elastic transmitter of power. It absorbs less power in itself than ropes. A number of textile ropes on one pair of pulleys never pull altogether as one. Each individual rope has a traveling speed of its own; consequently, there must be a loss of power, whereas a belt transmits the power from one pulley to another in one solid grasp. Belts and ropes both drive well when the distances from center to center are great, and the pulleys large in diameter. But a rope has no chance against a belt when the shafts are near each other, or the pulleys less than 4 ft. 6 in. in diameter. Under these circumstances a good belt will give splendid results, while the best of ropes are a constant annoyance. Main-driving leather belts should be manufactured so that when the joint is made, while the belt is in its place, it ought to present the appearance of an endless

* Paper read before the Millers' Convention, at Glasgow, June 16, 1885.

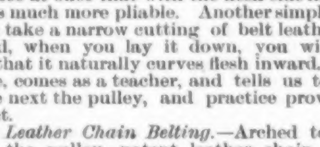
belt. After having been taken up once or twice during the first year, good belts, such as these, require very little attention during the subsequent years of their long life. If the belt is driving in a warm engine-room, it ought to get a coating of currier's dubbin three times a year. All belts having much work to do ought to present a clammy face to the pulley, and this condition can be best maintained by applying one coating of dubbin and three coatings of boiled linseed oil once a year. This oil oxidizes, and the gummy surface formed gives the belt a smooth, elastic driving face. A belt looked after in this way will always run slack, and the tear and wear will be inconsiderable. On the other hand, dry belts have to be kept tighter, because they slip and refuse to lift the work. The friction of the running pulley "burns the life" out of the belt while this slipping is going on. The driving face is made as hard as millboard, and as well polished as a millstone. Bushes are ground down, shafting worn, oil consumed, the belt killed and condemned, because the disease has been misunderstood. If a belt is wanted to do more work than was originally intended, by, say, an addition to the machinery of the mill, a very good plan of getting power is to run a second belt upon the top of the one in use. Do not connect them in any way, and the outside belt will work for itself, and do a large proportion of the driving.

By way of experiment, I have made four 6 in. single belts, running independently on the top of one another over 4 ft. driver and driven pulleys, transmit over 80 horse power, the belts traveling at a speed of 1,800 ft. per minute. Each of these belts did its own share of the work, and while running over its own circumference each gained a little over 30 ft. per minute upon the one below; so that the outside belt traveled over 90 ft. per minute more than the inside belt. The best leather for making belting is proved to be that known as "orange tan." This leather is made from the heaviest and best grown Highland ox hides. During the process of tanning, instead of swelling, as is the case with all bark tannages, this leather becomes thinner in substance, and weighs 45 per cent. less than if tanned with oak bark. The breaking strain, according to Lloyd's proving house test, is 45 per cent. greater than oak-bark tanned leather. There are life and spring in it not found in any other leather. For driving machinery this leather stands first. Long belts should never be made heavy, because the weight makes them swing to a certain extent. The heavier the belt, the greater the oscillation. Double orange tan belts will work as steady as ribbons up to 350 ft. long.

The Singer Manufacturing Company, when designing their new Glasgow factory, were nearly deciding in favor of ropes for the long distance driving. However, after testing the orange tan leather as to weight, working, and breaking strain, the decision was, "There's nothing like leather." There can be seen working at this factory every day between thirty and forty main driving belts up to 30 in. wide; nearly a dozen of them are long, being 150 ft. by 19 in., and of double orange tan. They run as straight and as steady as a line, and have only once been taken up.

Now comes the answer to the question often asked as to which side of a leather belt ought to run next the pulley. It is well known that by running the "grain," or smooth, side next the pulley, there is a considerable gain in driving power. However, by using the boiled linseed oil, as before mentioned, the flesh will soon become as smooth as the grain, and the driving power fully as good. A belt working with the grain side next the pulley really has a much shorter life than the belt running on the flesh side. The reason is, the one is working against the natural growth of the hide, while the other is working according to nature. Take a piece of belt leather and bend it with the grain side inward, and then bend it with the flesh side inward; you will see at once that with the flesh side inward, the leather is much more pliable. Another simple example is, if you take a narrow cutting of belt leather, pull it well, and, when you lay it down, you will at once observe that it naturally curves flesh inward. Nature, therefore, comes as a teacher, and tells us to run the flesh side next the pulley, and practice proves this to be correct.

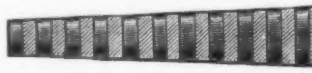
Patent Leather Chain Belting.—Arched to suit the curve of the pulley, patent leather chain belting is proving to be one of the best belts ever invented. According to this manufacture, the entire face of the belt



comes in equal contact with the entire face of the pulley. No unequal strain comes upon the rivets, as they have a level bed to lie upon. This belt is made a little thicker at the edges than in the center. It can be made to suit any curve of pulley. All that is wanted is a templet of the pulley on which the belt has to work. This class of belt transmits 25 per cent. more horse-power than a flat belt of the same width. Many engineers are in doubt on this point. In practice, however, the truth of this statement has been proved to be quite correct. A flat belt always retains a cushion of air between itself and the pulley, which prevents perfect grip. This air escapes through the spaces in the chain belt, and the edge leather takes full charge of the power which it has to turn.

I will only mention one example. Mr. John Smalley, of Mellor, Lancashire, was troubled with a 28 in. flat double belt not being able to transmit the power of his engines, therefore a quantity of the machinery had to stand idle. A belt of this class was made specially to test this question. That belt is now doing over 25 per cent. more work than the flat double belt could do. It works very steadily, driving as easily as possible. It is the most rapidly joined belt of any. The links have only to be interlocked, the rivet connection made, and then you have an endless belt which runs so straight and steady that it looks like what a belt ought to be. Quite a number of these belts are driving three and four roller mills, and are considered by the millers using them to be "perfection."

Half-Twist Belts.—This class of drive is sometimes the cause of much annoyance. A short belt has a poor life, and if the power wanted demands a wide belt, then the strain upon the outside of the twist becomes so great that bevel wheels and upright shafting have to take the place of a belt. In using ordinary flat belts for this class of drive, it will be observed that a large portion of the belt assumes a slack appearance on the inside of the twist, which leaves the pulley and does no work. Several plans have been tried to overcome this difficulty, such as splitting the belt up into two or three widths and securing them with cross connecting straps. But none has been so successful as the patent thicksided and tapered chain belt. The links may be 1 in. deep at the one side, tapering to ⅜ in. deep at the



other. By this formation a twist belt can be made to any width. It comes in contact with every inch of the pulley. The strain is taken up by the heavy side, the slackness is taken out, and the belt seems to work as well as if there were no twist to contend with.

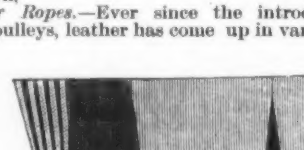
Cotton Belts.—These are very good for many sorts of drives, such as those of paper mills, dye works, wet spinning flax mills, and all sorts of works in which steam and water are present in abundance. They also answer well for outside driving. At our own works we have our own make of cotton belts transmitting power across yards from one building to another, in all weathers, with no other covering than a coat of boiled linseed oil, applied every two months. In warm countries these belts do remarkably well. The objectionable fraying of the edges has now been cured by applying our patent projecting leather edge. This edging is very securely riveted on with the copper wire machine, and is so placed that it meets the thrust of the shifting fork, and saves the cloth from being cut.

Jointing Belts.—Whether the belts are new or old, a properly made joint is of the first importance to all users of belting. The number of belt fasteners in the market is legion, some of them worthy of attention, and many of them not. A well-made butt-joint, with the lace holes punched in row of diamond shape, answers the purpose fully as well as any. Care should be taken that the holes do not come in line across the belt. A good lace, properly applied with all the strands of the lace running lengthways of the driving side of the belt, will last a long time and costs little. If a lap-joint is made, time should be taken to thin down the ends of the lap. Joints of this sort should be made to the curve of the smallest pulley over which the belt has to work. This plan removes the strain from the back of the lap, because the outside of the joint will be ⅛ in. to ⅜ in. longer than the inside of the joint. Double or single belting, lap-jointed, without being curved, makes the joint so very stiff that every time it travels on and off the pulley, a hinged sort of action takes place immediately beside the joint, and in a very short time the belt is torn across, and often condemned for being made of bad leather, and yet the goods may be of the very best quality.

Accumulations or Lumps on Pulleys and Belts.—Dust should never be allowed to gather into a cake either on pulley or belt, for if so, the fiber of the leather gets very much strained. The belt is prevented from doing its work, because this stranger defies the attempts made by the belt to get a proper hold of the pulley. When I see a belt so handicapped, I begin to think of the sufferings of a friend with a vicious corn.

Belts and Ropes Coming off the Pulleys.—When a bearing gets heated, the shaft naturally becomes heavy to turn. The belts or ropes having already the maximum power in hand they are designed to cope with, they refuse this extra strain, and will leave the pulleys at once or break. This accident directs the attention of those in charge to the belts or ropes, when time is taken up consulting as to what is to be done. Meanwhile the cause of all the trouble gets time to cool, and the source of annoyance is never discovered. Before a new start is made, all bearings are well lubricated. All goes smoothly, yet some one is blamed for the breakdown.

Leather Ropes.—Ever since the introduction of grooved pulleys, leather has come up in various forms



of driving rope. Up till now none of them have come to anything as against cotton or hemp rope. There is the ordinary cable-laid hide rope, the strands of which soon cut themselves into pieces by pressure and internal friction. There is also the "Combe" rope, which is made of a multitudinous body of long leather strands twisted together; the friction and pressure also soon cut them up. Then thereis the V-shaped solid leather rope, which is much too stiff and hard. The bottom plies get all cut and broken by the outside strain. There is the V-shaped rope with two or more plies of solid leather, with friction sections riveted on these plies. The openings left between these sections are meant to make this rope more pliable, and less liable to cut. It has done some work, but is not a success. There is the square solid leather rope that is now being made, the faults of which are the same as those of the solid leather V-rope. However, there is nothing like perseverance. The outcome of this desire to improve is the patent V-shaped chain rope (see sketch). This rope seems to possess all the qualities required to enable it to become the driving rope of the future:

1. It can be put on in a very short time, and can be shortened in a few minutes.
2. It offers four times the working contact of a round rope.
3. It will work well, whether long or short.
4. It will work well over small and large diameters.
5. This rope can be made to fit any form of groove.
6. Where textile ropes give trouble, we are willing to run a number of these on twelve months' approbation.

My remarks are finished. I hope I have made myself understood. I thank you, Mr. President and gentlemen, for your kind attention.

ON DISTRIBUTING LIGHT AND HEAT, AND SUPPLYING HEATED AIR TO ORDINARY GAS-BURNERS.

By FREDERICK SIEMENS, C.E., of London.

THE subjects of lighting and heating by means of gas have been very much before the public for some years past, and still continue to occupy a very prominent position. The influence of electric lighting upon gas lighting has been very great. People have been accustomed, at exhibitions and elsewhere, to brilliant illumination from single sources of light, and have called upon gas engineers to produce similar effects. Public interest has kept pace with the progress of improvements, and has led to demands for still further improvements, so that the requirements of practical illumination have increased by degrees to such an extent that it is impossible to foresee at present where and how this general tendency will end. In the same way as regards heating. Owing to the work of the Smoke Abatement Institution and to other causes, the public have had their attention drawn to the great and pernicious waste and inconvenience which are occasioned by the burning of coal in ordinary grates, and have been led to look upon the use of gas as a means of combining smokeless and economical with efficient heating. The author proposes to treat these two subjects in the order given, as being that in which they have been practically applied; and trusts that the results of his experience may be of interest to the members of the Gas Institute.

Until lately three main points only have been considered in any lighting application, viz., that the apparatus employed should be simple, both in its construction and in its use; that the light should be of sufficient intensity for the purposes required; and that the first cost and the maintenance of the plant employed should be very moderate. In public estimation, simplicity is the first *desideratum;* and hence a simple and direct form of illumination has always been preferred to a more complicated arrangement, even when the latter has been found more economical as regards first cost and maintenance and more brilliant in its effects. At the present time, however, in addition to these requirements, a purer atmosphere and a more pleasant temperature in our apartments are desired, which matters received very little or no attention in former days, when people were content with a simple dim light, and took little interest in sanitary matters. The regenerative gas-burner may be regarded as a combined lighting and ventilating apparatus, by the employment of which the close, oppressive atmosphere so unpleasant at large gatherings may be entirely avoided. In fact, it is the outcome of the demand for cooler and purer air in our apartments, combined with light of high intensity.

But besides the improvement of the atmosphere of our rooms, there is in the author's opinion another consideration, of the highest importance as regards artificial illumination, which has only as yet received partial attention, *i. e.*, that rooms should be lighted only by means of indirect rays or diffused light, the source of light itself not being directly visible. The illuminating power of the most novel appliances for the production of light having, for economical reasons, been made more and more intense, and therefore more injurious to the eyesight, it follows that the eye must be protected as much as possible from the direct action of the light, with the least possible loss or diminution of effect. In his glass-works at Dresden (where, for various operations, the workmen require a good light), the author has found that better work is done with well diffused light of low intensity than with direct light of a much higher intensity; the latter having an irritating effect upon the eye. In nature we find exactly the same conditions, for when the eye receives the direct rays of the sun, momentary blindness is caused; and, however bright the day may be, a person sees more clearly when the sun is concealed behind a cloud than when it is shining in full brilliancy, although the intensity of the light is much less in the first case. Thus in the twilight, when the sun is below the horizon, objects are much more clearly defined than in the full blaze of the sun, when the light is very much stronger.

In the lamp which the author has the honor to bring before the meeting, he has endeavored to protect the eyesight from the direct action of the source of light, without diminishing its power. It is with this object in view that he has arranged his new regenerative gas-light apparatus, with its automatic supply of heated air. These are shown in the diagrams exhibited.

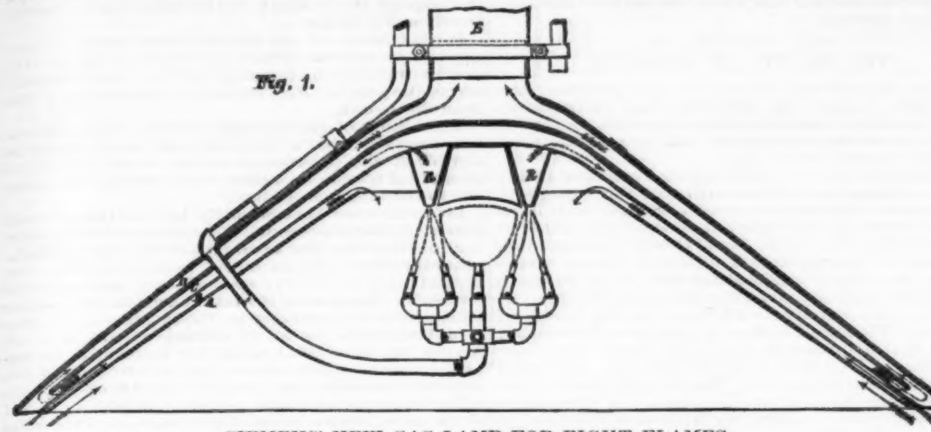
The construction of the apparatus will be understood from the following description: Four hoods, A, B, C, D, of sheet iron or other suitable material, are arranged within one another in such a manner that the products of combustion travel downward between B and C, and upward between C and D, while the air to be heated for feeding the flame passes upward between A and B. The dotted arrows indicate the direction of the outflowing currents, and the black arrows that of the inflowing air to supply the burners or jets. On the uppermost hood, D, a chimney, E, is provided, while the hood, C, is shortened below so as to allow a clear passage for the products of combustion from the space between B and C to that between C and D, and thus to the chimney. The hood, B, carries at its apex an inwardly projecting outlet, R, through which the products of combustion pass away as described, first downward and then upward, through the passages between the three upper hoods, into the chimney. The lowest or innermost hood, A, is open, so that the air may pass upward between the hoods, A and B, as indicated by the arrows, to fill the inner space of the hood with heated air. The inner surface of this hood acts as a reflector, and in its focus are placed one or more fishtail burners of the usual type. As soon as the hood, B, becomes sufficiently heated, through the action of the products of combustion passing between it and C, the air between A and B will become heated, and, diminishing in its specific gravity, will automatically rise and fill the upper portion of the cone inside the hood, A. By this arrangement, the gas-jets burn within an atmosphere of heated air, with which they are consequently permanently supplied, the temperature of the air increasing with that of the gas-flames, and the brilliancy of the light increasing in the same ratio. The action is perfectly automatic; for

* Paper read before the Gas Institute, London, June, 1885.

as the products of combustion pass away through the chimney, E, fresh heated air comes in at the same rate into the inner space of the hood, A, containing the gas-flames, to occupy the space which would otherwise be filled with cold air from the atmosphere below. The hot air which is supplied from the column of heated air formed between the hoods, A and B, will, on account

again tested. The consumption of gas was found to be reduced to 15·5 cubic feet per hour, and the illuminating power to be increased to 115 candles, being an average of 7·42 candles per cubic foot, or, allowing for loss by absorption, 7·74 candles per cubic foot. The difference between this and 3·180 candles, or 4·560 candles, gives the gain in light per cubic foot of gas

Fig. 1.



SIEMENS' NEW GAS LAMP FOR EIGHT FLAMES.

of its *lower specific gravity*, always fill the upper space inside the hood, A; thus preventing the cold air of the atmosphere, which is at least three times as heavy, from rising inside the hood, A, above a certain level, even in case of a disturbance in the atmsphere of the room. Thus no glass partition to exclude the cold air is required. The flame reflects its light directly downward, as also from the inner surface of the hood; and there is consequently an entire absence of shadows.

The light can be more or less concentrated or diffused, as desired, by varying the shape of the hood or reflector used. In some cases, where it is required to diffuse the light widely, or to diminish the downward radiation of heat, a bell shaped glass, with its apex upward, and its surface curving parabolically in a downward direction, may be employed, so as to cause all the rays of light either to be refracted or reflected horizontally. If it is only desired to reduce the intensity of the downward radiation of heat, clear glass should be employed; if, however, it is also desired to diffuse the light, opaque glass is requisite, and the light may be thus more or less diffused, as may be required. The glass bell is suspended on a wire net of large mesh attached to a metal ring below, upon which and upon the netting the glass rests, so that in case of accident the broken glass will not fall below. It allows of free access to the flame, and does not form an integral part of the apparatus, so that its employment will not cause any particular trouble or inconvenience. As the intensity of the light depends entirely upon the upcurrent of heated air, the hoods may have any shape most suitable for the reflector and for the purpose of diffusing the light, provided the height of the column of hot air between the hoods, A and B, be not relatively diminished.

The following tests of this lamp have been made: The burners or jets removed from the dome were tested with the rays horizontal. The consumption of gas was 20 cubic feet per hour, and the illuminating power 57·5 candles, or 2·875 candles per cubic foot. They were then placed at an elevation of 1 ft. 6 in. perpendicularly over a plane glass mirror placed at an angle of 45°, and in a line with the disk of the photometer. The distance from the standard light to the glass reflector was 18 ft. 6 in., which added to the 1 ft. 6 in.

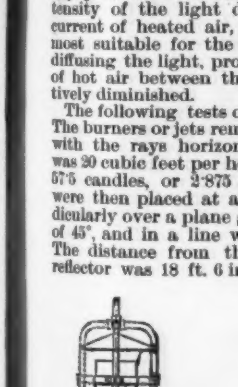


FIG. 2.
FOR TWO FLAMES.

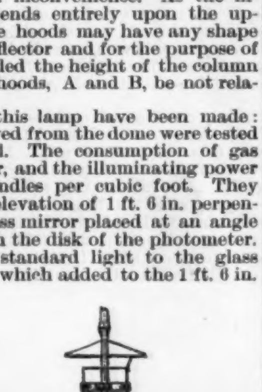


FIG. 3.
FOR FOUR FLAMES.

that the burners were placed above the reflector made together 20 feet, the distance at which the light to be tested has to be fixed from the standard light in the photometer employed. In this case the consumption was again 20 cubic feet per hour, and the illuminating power was found to be 55 candles, or 2·75 candles per cubic foot; so that it would appear that there was an absorption by the glass in reflection of 4·35 per cent. The burners having been fixed in the dome reflector, the lamp thus arranged was again tested, as in the last experiment. The consumption of gas was 20·5 cubic feet per hour, and the illuminating power 62·5 candles, or an average of 3·048 candles per cubic foot of gas, or 3·180 candles per cubic foot if the 4·35 per cent. found to be absorbed by the glass are added. The difference between 2·875 and 3·180 candles, or 0·305 candle per foot, gives the increase of light due to the use of the reflecting cone. After burning for some time, the lamp was

due to the regenerative arrangement, the gas burning within a highly heated atmosphere.

Particulars of Burners tested May 6, 1885.	Pressure of Gas.	Consumption in Cub. Ft. per Hour.	Candle Power.	Candle Power per Cub. Ft. of Gas.	Corrected for Loss by Mirror.
Gas-jets taken out of lamp...	Tenths. 10	20·0	57·5	2·875	....
Same jets, raised 18 inches, to reflect light on mirror.*	"	20·0	55·0	2·750	....
Same jets, burning in cold lamp	"	20·5	62·5	3·048	3·180
Same jets, burning in hot lamp	"	15·5	115·0	7·420	7·740

* This shows a loss of 4·135 per cent., owing to absorption by mirror.

This burner, therefore, completely fulfills all the requirements indicated in the introduction to this paper, viz.:

1. Only a small outlay for plant is involved; it is far cheaper than any other light apparatus, including the author's regenerative burners of earlier construction.

2. The saving in gas is very considerable, as the candle power per cubic foot exceeds that of the older regenerative gas-burners, and therefore that of all existing gas lights.

3. It is exceedingly simple as regards manipulation; being merely an application of the fishtail burner.

4. Repairs are not likely to be needed, on account of the simplicity of the arrangements; as has been proved by its use at the Dresden Glass Works during last winter. No trouble whatever was experienced; lamp glasses or globes not being required.

5. As the combustion of gas is very perfect, there is no likelihood of the air being vitiated by smoke, as is generally the case with other free-burning lighting apparatus. As, moreover, the products of combustion escape in an almost entirely cool state (their heat being employed in heating the incoming air), there is no difficulty in collecting and carrying them off in the same way as has already been done with the author's regenerative gas-burners of former construction. The apparatus thus performs the function of a ventilator—an advantage of the highest importance.

6. The last condition which this apparatus fulfills is the one which the author specially puts forward, viz., a perfect distribution and utilization of light, with the source of light concealed from direct view.

Although this last-named feature has not hitherto been generally recognized as an advantage in illumination, it will doubtless be properly valued as soon as its importance is admitted. There has been a tendency of late (to which reference has already been made) to employ sources of light of great intensity, with the result that on occasions of festive illuminations as well as at shows and exhibitions, people see very indistinctly, notwithstanding the brilliant display of light, on account of its dazzling effect. Attempts have been made to remedy this disadvantage by the use of opaque and frosted glass, and even of curtains; but this is only effected at the expense of the light. Thus, in the case of opaque glass, nearly half the light is lost; and even then the eyesight is not completely protected. In cases where light is necessary for industrial purposes (as in factories, workshops, studios, and offices), that mode of lighting will be preferred which is steadiest, simplest, and least injurious to the eye. This effect is realized by the application of indirect or diffused light, and it may therefore be expected to be employed before long in all cases where the quality of light is more valued than mere brilliancy. It will, no doubt, be also applied later on for other purposes, as the construction of the apparatus may be modified to suit any application. In some cases the lamps described in the present paper will be most suitable; while in others the old form of regenerative gas-burner—already well known, and much used in Germany, Austria, America, and other countries—will be applicable, especially in cases in which light has to be transmitted sideways or upward, or has to be concentrated in one direction, as in the case of lighthouses. There are so many special purposes and peculiar circumstances which have to be considered in any plan of illumination, that no one method of lighting is likely to be universally adopted; for which reason several of the existing forms will still continue to be used. The author, therefore, does not claim for his new burner a universal application, but he believes that its use will be very extensive, as it answers well all the requirements of ordinary illumination.

Of course, light may be diffused or transmitted indirectly by other means than those described in this paper, although, perhaps, not in a more simple or economical manner. The necessity for indirect illumination has, indeed, only made itself felt very recently, with the introduction of sources of light of great intensity, which dangerously affect the eyesight if directly looked at, without giving any better lighting effect. The electric light has been, to a certain extent, already treated in a similar way, by suspending arc lights at great altitudes, and, by means of reflectors, concentrating the light down upon certain areas. The intention has been, by this means, to illuminate whole towns or districts of towns from single sources of light. This can, in the author's opinion, be done if the concentration of the light is effected in a different way from what has been hitherto attempted, viz., by the employment of very much larger reflectors. In this way loss of light sideways, and the deep shadows that have been produced, will be avoided. It matters very little at what height the light is placed; the chief question being what area has to be illuminated, and then the form of reflector suitable for the purpose can be easily determined upon. The two apparatus exhibited show two reflectors of different kinds. The smaller reflector, concentrating the light upon a limited area below, can, if desired, have attached to it a deflector in the form of a bell made of opal glass curving downward in a parabolic form.

In conclusion, it must be remembered that illumination from above downward is in nearly all cases the preferable mode of distributing light, as Nature herself proves in having one light only; the sky being the diffusing agent by which the most perfect distribution of light is effected. Nature possesses indeed a gigantic reflector in the atmosphere and clouds; and the author has endeavored to imitate Nature's reflector in a way suitable to our imperfect means and conditions, and to the circumstances of each individual case.

As regards the second part of the paper, which refers to the heating of apartments, the author wishes to describe a regenerative gas-stove of his invention, by the application of which, with comparatively little cost, an agreeable temperature may be maintained within a room, the products of combustion being either carried away or partly condensed within the lower portion of the stove.

The stove (which is exhibited in the hall) consists of a metal cylinder about 1·5 meters high and 0·5 meter in diameter, on one side of which there is a open combustion chamber or fireplace, in which a gas-flame burns with great brilliancy, owing to its being supplied with heated air in the same manner as in the gas-lamp just described. As shown in Fig. 4, the products of com-

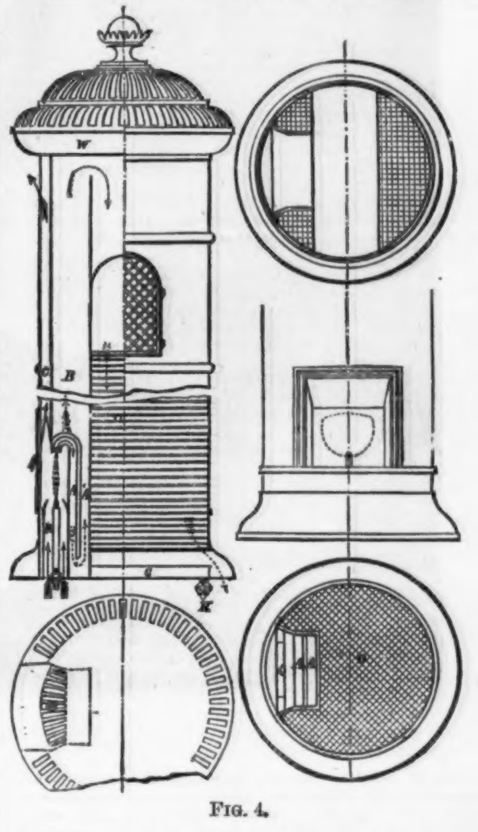


FIG. 4.

bustion from the flame first of all descend the channel, A, and then pass upward through A and B, and again descend inside the body of the stove or chamber, O. This chamber may be partly filled with loose material offering a large surface, such as slag-wool, through which the products of combustion travel from above downward, and, depositing their heat, pass away quite cooled either into the room to be warmed or by means of a chimney or ventilating shaft into the open air. From below, and also from the upper portion of the fireplace, there is provided an outer vertical channel parallel with the inner channel, B, through which air can circulate, escaping above into the room or apartment to be warmed. A similar channel, R, below supplies the burner with heated air. The means by which the draught of the stove is effected is peculiar; but the result is quite satisfactory. The chimney proper which produces the draught is the vertical channel, B; and it is due to its action that the hot products of combustion pass first downward for regenerative purposes, then upward to act as a chimney, and eventually down again inside the body of the stove, to escape at the foot, as already mentioned. This stove, thus arranged, acts independently of any chimney or other artificial source of draught, and consequently may be placed anywhere.

The principal portion of the heat of the products of combustion is given up in the channel, A, to be transferred to the air for combustion, which enters from below through the channel, R, to combine with the gas. The combustion is, in consequence, very perfect;

the flame attaining a high temperature, and radiating intense heat and light. The products of combustion which pass through the chimney, B, still retain, however, sufficient heat not only to produce the requisite draught, but also to overcome the upward tendency of the products of combustion in the chamber, O, in the body of the stove. This action is assisted by the partial vacuum produced by the condensation, at the foot of the stove, of the condensable gases and of the steam formed by combustion of the hydrogen contained in the gases burnt. The heat in the chimney, B, also serves to produce the circulation of air in the channel, C, in consequence of which a current of warm air passes into the room. The top of the stove is provided with a vessel, W, containing water, which will become heated; the vapor produced moistening the air of the room. The heat produced by the combustion is utilized in three ways: (1) By direct radiation from the flame; (2) by a circulating current of warm air produced in the vertical channel, C; and (3) by the warm body of the stove itself. Those who know how difficult it is to abstract all the heat of a flame by direct contact will appreciate the advantage of having also placed at their disposal means of utilizing the radiant heat of a brilliant flame. It is entirely owing to these circumstances that it is possible to cool the products of combustion to such an extent as to be able to condense the aqueous vapor and the deleterious condensable gases, without heating the surfaces of the stove so high that they become unpleasant. The liquid thus formed is collected at the bottom of the stove in the vessel, G, to be drawn off from time to time by means of the tap, H, to prevent its overflowing.

These gas-stoves offer many advantages. The gas is burnt in the most economical manner; there is a cheerful flame burning in an open fireplace; the stove itself and the circulating air are only heated to a moderate temperature, and thus no unpleasant smell is produced, because the organic matter contained in the atmosphere does not smoulder or singe, as is the case with stoves heated to a high degree; while the organic matter drawn in with the air for combustion is burnt in the flame, and condenses with its noxious vapors. As gas is the fuel employed, there are no ashes to remove; and, as the combustion is perfect, the stove is quite clean in use, neither smoke nor soot being formed. As, moreover, the greater portion of the injurious gases contained in the products of combustion are condensed, it appears to be unnecessary to have a separate chimney, and the stove can be placed in rooms containing neither chimney nor ventilating shaft, although the author prefers to connect it with a chimney or shaft if available.

The management of the stove is extremely simple, as there are no valves, doors, or dampers (all actions going on automatically). It is only necessary to turn on the gas, when required, and light it. The sides and back of the fireplace are either painted white, or covered with white refractory material, so as to radiate out the heat. When it is desired to tone down the light, this can be done by means of a screen or door of colored or opaque glass, by the use of which fanciful designs may be produced. The size and form of the stove may by varied, and instead of one burner, several may be employed; but the important advantage and novelty of the stove are the warmth and comfort obtained by means of the simple arrangement described.

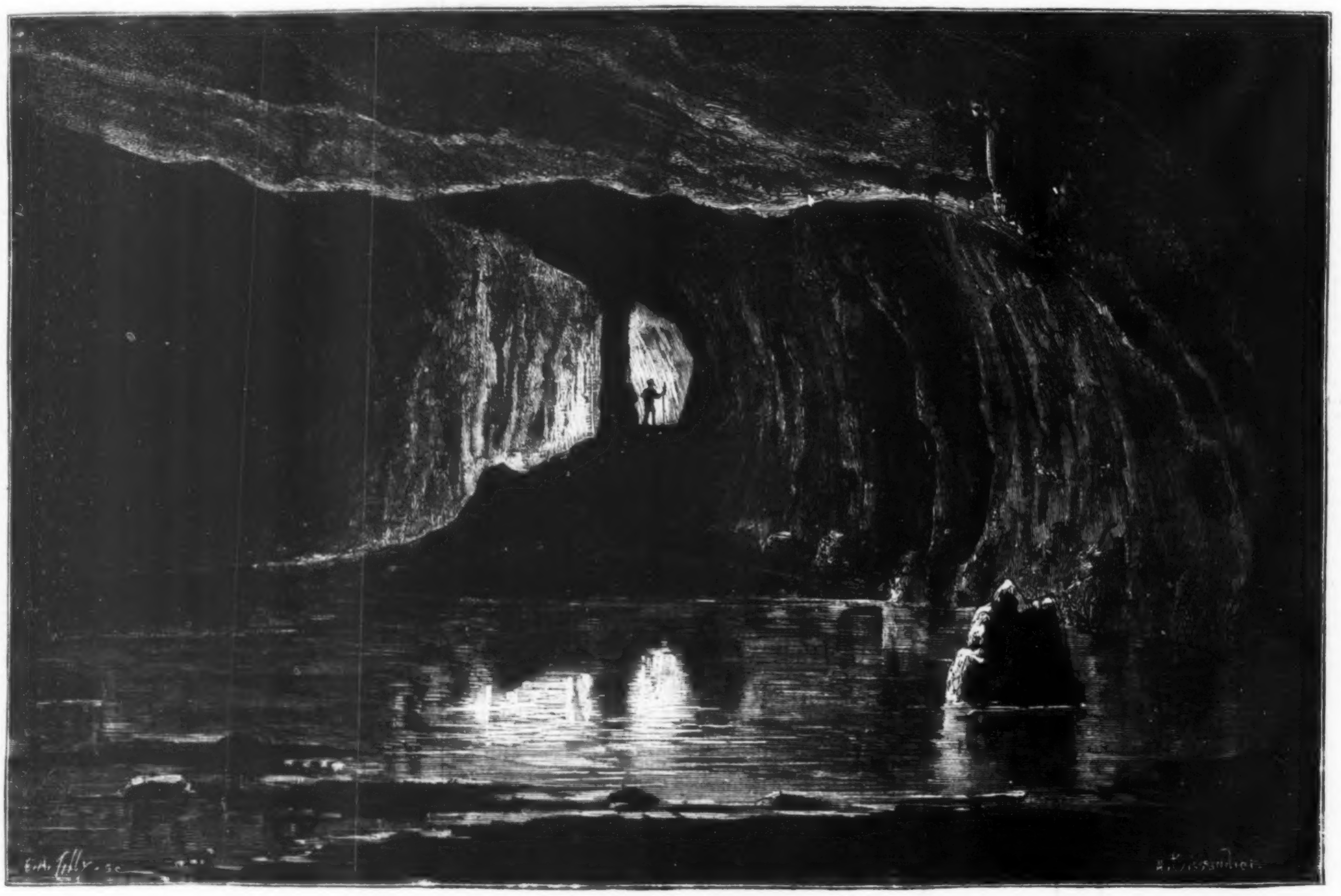
In conclusion, the author would wish to thank the Gas Institute for the gold medal with which they presented him last year in recognition of his labors in effecting economy by means of the regenerative gas appliances; and while referring them to the paper he read before the Iron and Steel Institute in September last, for a description of the latest development of the regenerative gas furnace, and of the action of radiant heat when at high temperature, he trusts that this new application of the same principle to domestic heating and lighting (the economy of which is due to the radiant heat from an intensely white flame) will prove of interest to the members of this, the representative institute of the gas industry.

THE GROTTO OF OMBRIVES.

AMONG the different caverns of the Pyrenees that have been explored by scientists, that of Ombrives (near Tarascon) is certainly one of the most beautiful, from a picturesque standpoint, and one of the most curious as regards archæology.

This cavern has been hollowed out by natural agents (such as dislocations of the earth and the passage of water-courses supersaturated with carbonic acid) in the lower Cretaceous limestones that skirt the valley of Ariege to the west. At the foot of Ombrives Mountain is situated the thermal station of Ussat-les-Bains, whose springs have their origin along one of the fractures which have partially given the grotto its direction. It requires but a half hour's ride to reach the mouth of the cave. The ascent is effected amid the wildest chaos, which is still further increased by blocks that have been detached by frost from the cliff that overhangs the entrance to the grotto. The mouth, which is hidden by a large bank of caved-in earth, is of stupendous size, and, if rid of leakages, might be now inhabited as it was in former times.

When we enter this immense palace, where, according to a legend, the presumptuous Pyrene was enthroned we see that the grotto is divided into two passageways.



THE GROTTO OF OMBRIVES.

The one to the right opens in view of Tarascan, and ends in a platform that is reached in a few minutes. Herein are found numerous vestiges of human habitation during the epoch called the Age of Polished Stone. In this passage, nature has been lavish of the oddest of stalactites. Here are pendent women, there are fat geese, and further along, a cathedral chandelier.

The passage to the left, which is the larger, is about 1,300 feet in length, and abruptly terminates in a narrow passage that formerly could only be traversed by crawling. All at once we enter an immense hall. Here there are no more stalactities, and the light of the torches dimly illuminates a vault that rises like that of a cathedral, while before us we behold a vertical wall at whose summit may be seen the upper grotto. We are mute, amazed, and we ask what motive the man was inspired with who first dared to climb up this formidable passage.

In former times, fire ladders, fixed upon as many ledges of rock, permitted of reaching an aperture that is now easily reached by a stairway which is here dug out of the rock, and there suspended over the abyss like the gang-plank of a ship. Upon the landing where the steps end, there opens a passage which an accumulation of rocks render it dangerous to traverse. It debouches, after obliging the visitor to make a troublesome ascent, in the largest and most curious hall—the "Cemetery."

As we advance into the cavern the vault vanishes in the distance, regularly and majestically, and we behold enormous stalactitic concretions that still bear more or less appropriate names. A lake, whose extent varies according to the season, often occupies the entire width of the cavern, and extends to a length of over three hundred yards. This is partially shown in the accompanying engraving. After crossing it over points of rocks and stalagmites, we continue our walk over a space of a few hundred yards until we find ourselves in front of two galleries. Of these, the one to the right unexpectedly terminates in a precipice, and it requires the use of ropes to reach the floor below. At the base of this wall, there is quite a large hall, which itself ends in a second precipice that no one has ever descended. There is here, doubtless, a point of communication with the large grotto of Niaux, in the calcareous rock above the river Vic-de-Sos.

In the gallery to the left, the floor, strange to say, consists of water-worn flints and blocks of granite. The path is traversed by a fissure; and one soon reaches the end of the grotto, after walking a distance of a mile from the mouth.

The beauty of the spectacle removes from this subterranean visit what a cowardly mind might find of the terrible in the presence of so long a walk by the red glimmer of torches in a place that seems to be leading one to the kingdom of Pluto.

Let us now see what scientific interest this wild and imposing retreat presents. Like almost all other cases, that of Ombrives has in all prehistoric times offered a natural refuge to the primitive populations that lived in that point of the Pyrenees which is now called the Valley of Tarascon. Beneath the immense portico which forms the entrance to the cavern, and which is well illuminated by an abundance of soft light, are heaped up ashes that mark the location of the fireplaces around which entire families lived in that prehistoric time called the Age of Polished Stone. Granite mills, fragments of coarse pottery, polished stone and diorite axes, broken bones of ruminants, and the entire absence of metallic objects attest the presence of man at quite a primitive epoch. I have for a long time assimilated such epoch to that of the first habitation of the lakes of Switzerland.

Just alongside are found other fireplaces that have been built by human beings of higher civilization, as attested by the presence of glass ornaments and finer pottery. Here too have been brought to light fragments of bronze and iron objects.

But it was especially in the place that we have called the Cemetery that lay the most interesting and abundant of the objects that have ever been found in the cave. Very numerous human skeletons, collected in groups, were found mingled with fragments of pottery, large bracelets, pins, hooks, etc. Iron ornaments, collars of perforated dogs, teeth, axes of polished jade, fragments of bones of various animals (such as the ox, deer, sheep, little bear, etc.), and charcoal.

To say what historic or prehistoric age such an assemblage of objects and human skeletons was connected with, remained a problem to me, as I have already said in various publications. But, in studying the arrangement of the place, the manner in which the skeletons were distributed in the Cemetery, and the nature of the objects (nearly all of them ornamental and toilet ones), and seeing the limited quantity of animal remains, and knowing that the largest number of skulls found showed the presence especially of women and children of a Caucasian type, it is allowable to suppose that we are not in presence here of a dwelling-place like that whose existence at the mouth of the cave has been mentioned. If we likewise recall the historic fact pointed out by Cæsar in his Commentaries that he caused the inhabitants of the Pyrenean valleys invaded by his army to perish in the grottoes in which they had taken refuge, it is permissible to base upon this now well known, but unexplained, prehistoric deposit a theory which seems to be in accordance with the facts observed.

The deposit in this cemetery apparently consists of

the remains of a historic, pré-Roman population, composed especially of women and children who had taken refuge in this part of the cave in order to remain in safety here for some time, and who had been deprived of the means of getting over the precipice again in order to regain the path that had brought them hither.

Such is the idea that I put forth a few months ago before the Archæological Congress of France, after getting it to study *in situ* all the conditions of the deposit. The association accepted the explanation that I thus gave of that still mysterious point of the formation of the archæological deposit in the cemetery of the grotto, as being up to the present best in keeping with the facts observed.

The legends based upon the facts that I have pointed out have doubtless originated at very ancient epochs.

The existence of human bones in the grotto is mentioned by Elias Appamiensis, a historian of the 16th century; Holagrai, another author of the same epoch, likewise expatiating upon the marvels of the country of Tarascon, cites the presence of the Ombrives bones, which he invokes as marking a great antiquity.

Such is the grotto of Ombrives, which we shall no longer have the right to call, as formerly, the "grotto of ladders," since, thanks to the liberality of the general congress and to the solicitude of Mr. Paul, prefect of Ariege, that dangerous mode of ascending the precipice which separates the two grottoes has been replaced by a solid stairway that even the most timorous of women can ascend. Consecrated without doubt to the god Humber, whom our Iberian ancestors adored, the grotto of Ombrives is the most beautiful of all the caverns of Tarascon, which, according to Archiac, contains "the principal elements of a human chronology completer than in any country of an equal surface."—*F. Garrigon, in La Nature.*

PREMATURE APPEARANCE OF THE PERIODICAL CICADA.

By PROF. C. V. RILEY.

To the Editor of the Scientific American:

Under the above caption, Prof. Lester F. Ward, a well known botanist, published in *Science* for June 12th last an article which both for its unwarranted misstatements and reflections on the writer justified severe criticism. I sent to *Science* a courteous reply of less length than the original article, and this reply appears in that journal for July 3, but in a mutilated and weakened form. In the belief that the matter will be of sufficient interest to your readers as a sequel to the "Notes on the Periodical Cicada," published in SCIENTIFIC AMERICAN SUPPLEMENT No. 495, I send you herewith the reply as I wrote it and wished it to appear.—*C. V. Riley.*

REPLY TO PROF. WARD AS WRITTEN FOR *Science*.

The communication of Prof. Lester F. Ward, on the above-named subject, on p. 476 of *Science*, will no doubt surprise other members of the Biological Society of Washington as much as it did the undersigned. To appeal from the Society before which the discussion took place to a journal in which nothing in reference to the matter had previously appeared is not so much, perhaps, out of the way; but to give an *ex parte* and inaccurate account both of our private conversation and of the discussions before the Society is certainly unjustifiable, and obliges reply.

As the fullest refutation of his most serious charge I quote, *verbatim* as read, the following from the closing portion of my late remarks before the Society:

"A few precursors are not infrequently seen the year preceding or a few laggards the year following the general appearance of a given brood; but they are observed during the same season of the year. Development may be expedited by artificial heat during winter or spring, and we may safely assume the converse.

"In this connection it will be remembered that at one of our last autumn meetings, Prof. L. F. Ward gave us some experience to the effect that he heard the song of this Cicada in October last. There is no other record of its ever having appeared during that month, and the evidence upon which Prof. Ward based his statement, viz., his recognition and recollection of the song, would be rejected by every serious entomologist, having in mind the many other species that exist.

"So much is this the case that Dr. Asa Fitch, the late entomologist of New York, when he heard in Illinois, on September 26, a note that was much like that of *Cicada septendecim*, though somewhat shorter, preferred to refer it to some autumnal species. Yet, as will also be remembered, I gave our fellow member the benefit of the doubt, and indicated my appreciation of his observing qualities by endeavoring to show that such late occurrence was not impossible, and might be a result of the unprecedented warm October. Prof. Ward tartly remarked that he was 'glad the theory accorded with the facts,' since he could not be mistaken, as he had become so familiar with the note when a boy in Illinois, as it filled the woods *all through the summer*. And in those words he destroyed credibility in his evidence in this case, for the notes of *Cicada septendecim* cease by the beginning of July."

I then recalled, in pleasantry, Prof. Ward's rejection, at a previous meeting, of evidence, because inexpert, as to the occurrence of hybrid oaks, and showed that upon evidence of faulty memory as to the season when *Cicada septendecim* was heard by him when a boy, and upon his own ground of rejecting inexpert testimony in memory of a visual impression as to hybrid oaks, we must reject his inexpert testimony in memory of an auditory impression as to *Cicadas*. The remarks quoted above show further:

1st. That I nowhere pronounced his Virginia observation "wholly worthless" nor the occurrence "impossible as contrary to all canons of entomology." There is, I opine, a difference between Prof. Ward's judgment and the "canons of entomology."

2d. That there was no occasion to remind me of that which I had just previously recalled to the Society, and that therefore I could not "have forgotten" it. The astounding inaccuracy of his statements in this regard is sufficient to weaken all trust in his memory, but there is the following additional evidence in his article to impeach his testimony.

Prof. Ward in his private conversation with me, made no attempt to describe the notes of October last, but simply affirmed his recollection of them as similar to those of *C. septendecim*. His description in *Science* is of one of the notes of the species, and he seems to be ignorant of the fact that *Cicada septendecim* has several very distinct and variable notes. He has probably been misled by the abnormal condition of things the present year in the District of Columbia, where the English sparrow has so prevented the full maturity of the males, and decimated their ranks, that the more characteristic noises, and those most apt to be recollected, have scarcely been heard. This has been a common remark among entomologists who recollected former visitations in other parts of the country.

There is other evidence in his article that would further weaken reliance on his memory. He is not certain whether it was the year 1854 or 1855 (it was doubtless the former) when his boyish mind was first impressed; the *Cicada* in question does not leave its withering blight "on all the vegetation," but avoids most conifers and succulent plants. But these are trifling compared with the other instances given.

Finally, Prof. Ward will convince no one that I was ever guilty of speaking of the note of *Cicada pruinosa* as "precisely like" that of *C. septendecim*, though the mature and louder note of the latter much more nearly resembles that of the former than he seems to imagine.

C. V. RILEY.

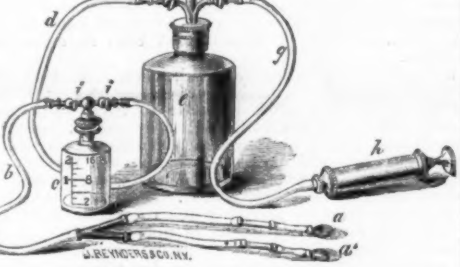
Washington, D. C., June 17, 1885.

ARTIFICIAL EPISTAXIS.

By J. LEONARD CORNING, M.D., New York.

IT has long been the practice among certain practitioners to resort to local bloodletting about the head and posterior aspect of the neck, with the object of exerting a derivative effect upon the intra-cranial blood. Medical literature abounds in histories which are supposed to illustrate the efficacy of such procedures. Where the amount of blood withdrawn has been large, an undoubted intra-cranial depletion has been produced, chiefly referable to the abstraction from the quantity of the blood as a whole, and not to the local effects of the operation. When, however, the amount of blood withdrawn from the circulation is small, it is questionable whether the local effect upon the circulation of the brain is at all appréciable. This lack of effectiveness is in great measure due to the fact that, in abstracting from the head and neck, the circulation in the external carotid is chiefly affected.

In contra-distinction to the unsatisfactory results obtainable from local bloodletting, as above described, are the excellent therapeutic effects which sometimes result from an ordinary "nose-bleed." Literature con-



tains many instances of headaches spontaneously relieved, epileptic attacks aborted, and the complexus of symptoms resulting from cerebral congestion exorcised by a spontaneous hæmorrhage from the nasal cavity. To what is this benignant influence of an ordinary epistaxis attributable? The answer, I believe, is not far to seek, the whole question being readily understood when we remember that the anterior ethmoidal artery is a branch of the ophthalmic, which latter artery in turn derives its blood from the internal carotid. When, therefore, epistaxis takes place, the terminal branches of the ethmoidal artery, which are distributed about the anterior portion of the septum and nasal cavity, are liable to rupture; or, if the immediate branches of the artery itself are not injured, then are some of its anastomotic communications sure to be broken. In either case the result is the same—an ultimate abstraction of blood from the cerebral circulation, by way of the ethmoidal, the ophthalmic, and the internal carotid.

Guided by the theoretical and practical considerations referred to, I have inferred that it would be a matter of some practical value if an apparatus could be devised by means of which it would be possible to abstract blood from the mucous membrane on each side of the septum—a territory corresponding to the distribution of the anterior ethmoidal artery. The apparatus depicted below is the outgrowth of those reflections. It consists, in the first place, of the jar (*e*), which is connected with the air-pump (*h*), by means of which it is possible to cause a vacuum in the vessel (*e*). The gauge (*f*) registers the degree of approach to a vacuum. An India-rubber tube connects the jar with the small bottle (*c*), which is provided with a scale. A bifurcated tube (*b*) connects the bottle with the two small cupping bowls (*a a'*); the latter are sufficiently minute to admit of their introduction into each nostril respectively. As they are provided with India-rubber garnitures, it is possible to adapt them accurately to the sides of the septum.

The mode of employment is simple enough. The cupping bowls having been introduced, a small scalpel is inserted in turn beneath the edge of each, by means of which the mucous membrane of the septum is slightly scarified. The cupping bowls are then connected with the vacuum jar and with the bottle by opening the appropriate stop-cocks. These valves (*i, i, i, i*) require no explanation, as their function is self-evident from the situation which they occupy. Short segments of glass tubing, inserted in the India-rubber pipes below the cupping bowls, enable the operator to observe whether the blood is flowing properly, or whether further scarification is necessary. As the blood flows into the graduated bottle already described, it is possible to determine with accuracy the amount removed.

The advantages of such an apparatus over ordinary leeches are great; it is only necessary to refer to the danger arising from the possible migration of the latter into the upper, inacessible recesses of the nasal cavity to make this point clear.

An instrument of this kind might, perchance, find a further application in gynæcology and other branches of surgery, for the purpose of abstracting blood from the vagina, the rectum, and other cavities. As for myself, I have never had occasion to employ the device otherwise than in the exigencies arising in neurological practice.

Finally, it may be well to note that the previous application of cocaine to the membrane of the septum, by means of the spray or tampon, renders the little operation of scarification practically painless. In the case of a gentleman from whom I recently abstracted an ounce and a half of blood with the mechanical leech above described, I was able to prevent the slightest unpleasant sensation by the use of a four per cent. solution of the hydrochlorate of cocaine.—*N. Y. Med. Jour.*

ODORS OF THE SKIN AND ITS APPENDAGES.

THE perspiration and the various cutaneous secretions impart a peculiar odor to every human being, as well as to each of the inferior species. This physical characteristic, of which, in general, we are hardly aware, is very acutely perceived by those persons in whom the olfactory sense is exceptionally developed. It is well known that many savages, as Indians, negroes, etc., can smell each other at long distances, just as a hound follows up his master by the scent. Individual instances of a similar character, but much more extraordinary, are not unknown in civilized society. Thus, Cadet de Gassicourt, in the *Dictionnaire des Sc. Méd.*, speaks of a young lady who could distinguish men from women simply by their odors, and who could not endure the smell of her bedclothes after any one else had handled them. In the *Journal des Savants* for 1684, we read of a Hungarian monk who was able to decide in the same way upon the chastity of females. The thing is not so very wonderful; we ourselves are acquainted with a physician who makes a specialty of diseases of woman, and whose nose informs him with unfailing accuracy whenever a patient is menstruating. The odor of the skin is rarely a pleasant one. Alexander the Great, according to Plutarch, exhaled the perfume of violets when he perspired, and in modern times Malherbe, Cujas, and Haller are said to have diffused an agreeable odor of musk. In ordinary individuals, the cutaneous odor is sulphurous and somewhat repulsive. Old Ambrose Paré observes that this is especially noticeable in the red-haired and freckled. Dark-complexioned persons smell of prussic acid; blonds, much more feebly, of musk. Fat persons are more odorous than lean ones; the former frequently have an oily smell, due to an excessive formation of fatty acids in the sebaceous secretion.

Age exerts a considerable influence on the cutaneous odor. Nursing infants have a peculiar sourish smell, caused by the butyric acid in their milk. Bottle-fed children smell of strong butter, cow's milk being so much richer than woman's in the oily principle. After weaning, a baby's odor becomes less decided, and, it is said, more agreeable. The human male, at the period of puberty, exhales a characteristic odor, which, though less pronounced, is similar to that of an animal in heat. This odor, which is one of the leading symptoms of what Bordeu calls the *seminal fever*, is more strongly marked in those who are continent. It is probably caused by the absorption of the spermatic fluid into the circulation and the elimination of its odorous principles through the skin. At all events, it is certain that it disappears as soon as the reproductive organs become enfeebled. In old age the skin exhales an odor which has been compared (without any metaphorical intention) to that of *dry leaves*. It is possible, therefore, to tell, by the sense of smell alone, if not the exact age of a person, at least the period of life at which he has arrived.

The influence of race upon the cutaneous odor, though perhaps less familiar, is quite as indisputable. The inhabitants of southern latitudes do not smell like those of the north. Their cutaneous functions are more actively performed. "The human flower," to use an expression of Goethe's, like the products of vegetation, is more highly perfumed in warm climates. This is especially evident in negroes, whose rank, ammoniacal odor, unmitigated by cleanliness, is attributed by Pruner-Bey to a volatile oil set free by their sebaceous follicles.

The nervous system has a very decided action upon the cutaneous odor, which quite frequently is heightened or modified by mental excitement, depressing passions, and neurotic disease. Cambrini has recorded the case of a young man who, having been crossed in love, became violently jealous, after which his whole body exhaled a fetid, sickening, and very tenacious odor. Dr. Hammond, of New York (*Med. Rec.*, July 21, 1877), speaks of a hypochondriac whose skin diffused the fragrance of violets; of a hysterical female who smelt of pineapple during her paroxysms, and another who perspired on the left half only of her chest, whence she exhaled an odor like that of the iris; her sweat, when analyzed, was found to contain a butyric ether. In cases of localized perspiration, these curious osphresiological anomalies are not at all uncommon. Schmitt knew a man who labored under a hyperidrosis that affected his hands only, and smelt like sulphur. Orteschi met with a young girl who exhaled, without any possibility of fraud, a strong odor of vanilla from the commissures of her fingers. Barbier mentions the case of a captain of infantry, the upper half of whose body was subject to an offensive perspiration which resisted all treatment, and finally obliged him to resign his commission. All these are examples of disordered innervation. Thus, as Hammond remarks, we perceive that the phrase "odor of sanctity" is not a mere figure of speech; it embodies the idea of a *holy neurosis*, which imparts to the skin a perfume more or less agreeable—at least during the actual access of the devotional ecstatic paroxysm.

The foregoing facts are curious merely. We now come to others which are of practical importance. In lethargy (hardly ever witnessed except in hysteric subjects), the very perspiration has a cadaverous odor,

thus adding another touch to the perfect picture of death already presented by this condition. This odor, there can be no doubt, has aided in the production of some lamentable mistakes.

The smell given forth from the skin in mental disorders is thus described by Fevre, in his work on the alterations in the cutaneous system arising from insanity (Paris, 1876): "The odor of the sweat in lunatics is of a very peculiar nature. Fetid and penetrating, it resembles the emanations from hands kept constantly closed, and is allied to those of the yellow deer and of mice. It is met with more especially in subjects of general paralysis and confirmed dementia. It impregnates the garments, bedclothes, and furniture of the patient, and even pervades his apartment, and is exceedingly tenacious, *despite the utmost attention to cleanliness.* This odor is so characteristic that Burrows declares *he would not hesitate, even in the absence of other evidence, to pronounce any person insane in whom he might perceive it.*" Another English alienist, Dr. Knight, goes still further, claiming that the absence of this symptom enables him to discover when insanity is feigned.

The affection to which Hebra has given the name of *bromidrosis* consists in an offensive odor of the skin resulting from an abnormal condition of the *materia perspiratoria*, without any increase in the quantity exhaled. It may be confined to particular portions of the body. *Bromidrosis pedum*, for example, is quite a common disorder. Even kings have not always been exempt from this odious infirmity—witness some of the stories told about "Le Roi Soleil," Henry of Navarre, whose neighborhood was almost insufferable to his courtiers, and whose very mistress reproached him with smelling "like a carrion."

The inguino-vulvar and inguino-scrotal perspirations possess an aromatic odor closely akin to that of the genital region in either sex.

The axillary sweat owes its peculiar redolence to the alkaline caproates; also, to certain volatile and odoriferous free acids; for, as Robin observes, none of these bodily odors is caused by any single element, but always arises from a combination.

Hyperidrosis of the axillæ is not uncommon. It is especially apt to occur when the body is unclothed, and, in women, during the catamenia, at which period it diffuses an aromatic odor of acids or of chloroform.

Localized sweats, almost always of tropho-neurotic origin, have usually a strong smell. This is probably due to maceration of the epidermis in the effused fluid, epithelial desquamation being also of frequent occurrence in all such nervous conditions. Weir Mitchell has observed that in lesions of the nerves the corresponding cutaneous region exhales an odor like that of stagnant water. This, we believe, is owing to a disturbance of the epithelial nutrition, rather than to any actual alteration of the sweat.

The ingesta, whether nutritive or medicinal, readily eliminate their odorous principles through the skin, and thus exert an influence upon the cutaneous odor. Garlic, alcohol, coffee, truffles, valerian, musk, turpentine, tar, sulphur and its alkalies, the fetid gum resins, ethers, angelica, benzoic acid, iodine and the iodides, phosphorus, etc., transmit to the integument their respective odors, more or less modified, according to the functional activity and also to particular idiosyncrasies. Copaiba diffuses its telltale fragrance in the same way. Sulphate of potassa is decomposed within the organism, and imparts to the sweat a hydrosulphurous odor. Phosphate of zinc causes garlicky smelling perspiration, etc.

In acute alcoholism the perspiration often has the odor of aldehyde, a peculiarity of value in diagnosis, as serving to distinguish the lethargic form of intoxication from apoplexy. Finally, I have noticed in the case of a lady who was taking Fowler's solution of arsenic, the occurrence of very offensive axillary sweats, which ceased when the medicine, at her earnest request, was discontinued.

Sufferers from incontinence of urine smell of this fluid, or else like mice. Similarly, constipation gives rise to a fecal odor of the skin, which, when perceived by the subjects themselves, frequently aids in producing hypochondria, a condition to which this class of patients is always liable.

The "hospital odor" is essentially variable in character, being chiefly caused by an aggregation of cutaneous smells. Hence it is that the wards devoted to women and children are perfumed with butyric acid, while those of men proclaim the presence of alkalies and ammonia.

In gout, the cutaneous secretions exhale a peculiar odor, likened by Sydenham to that of whey. Icteric patients smell of musk; syphilitics, of honey; scrofula is marked by the odor of sour beer; intermittent fever by that of fresh bread. In diabetes, when there is perspiration, it smells like hay, or rather, according to one authority, like acetone; Bouchardt thinks that the odor in this disease is intermediate between that of aldehyde and of acetone, being due to a mixture, in different proportions, of those two bodies.

In cholera, Drasch and Porker have noticed an ammoniacal odor, which they attribute to an elimination of urates in the sebaceous secretion.

In women recently confined and during the milk fever, the perspiration, especially at night, has a sour smell. Under the influence of pestilential maladies, the skin, according to Biemerbrock, exhales a peculiarly agreeable odor. Strange to say, this old time observation has been confirmed by Doppner, who says that all the plague patients at Vetlianka diffused an odor resembling that of honey.

In febrile conditions generally, the outer integument develops a sort of moist odor which is quite indescribable. Contagious fevers, as also the virulent disorders (rabies, glanders, and malignant pustule), are accompanied by a putrid smell.

In dysentery, the sweat reveals an unmistakable odor of the dejecta, as is strikingly evident on entering a hospital ward devoted to this complaint.

In typhoid fever, the cutaneous odor is remarkable. Behier calls it an *odor of blood*, and Fred. Berard says that it will attract the flies even before life has left the body. However slightly manifested, it is always the immediate forerunner of death. Dr. Althaus reports that Skoda has never been misled by this indication, and Crompton, of Birmingham, also mentions it as an important clinical symptom. This effluvium of the moribund is quite unlike the death smell itself, which again is also *sui generis*, and not at all allied to the odor of putridity.

Classical authorities are quite at sea about this typhoid emanation. It is truly what Behier describes it, an odor of blood. The *mouse-like* smell belongs more properly to typhus. It is consequently absurd to maintain, as Hjaltelin does, that these two fevers are marked by the same odors, and to infer from thence their mutual analogy.

A putrid odor, of variable character, is observed in pyosepticæmia, scurvy, bilious remittent fever, and the watery cachexia, or Egyptian chlorosis, of Griesinger. Recently established theories concerning the alterations caused by these disorders in the cutaneous secretion afford an explanation of this symptom. As for the ammoniacal odor which has been remarked in the course of cerebral affections, we think, with Lallemand, that it is often caused by an incessant urinary overflow.

In acute articular rheumatism, the sweat becomes more acid in proportion to its abundance, especially about the swollen joints. Its odor becomes markedly sour and pentrating. Some authors attribute these qualities to an excess of lactic acid, but are they ignorant that this latter is itself without smell? The odor in question is clearly due to the presence of acetic and formic fatty acids, whether these exist originally in the rheumatic sweats, or result from a transformation of the cutaneous secretions in their entirety, and not at all (as Ernest Besnier contends) to the abundance of the sweats, and their retention and decomposition, favored by a high temperature, by the immobility of the patient, and by the saturation of his long-worn garments. In refutation of this latter idea, it is sufficient to point to the profuse perspirations in phthisis, which never smell like those of rheumatism; neither can the rheumatic odor be prevented by frequent changes of linen or by the utmost attention to cleanliness.

In miliary sweats, the odor, at once acrid and nauseating, has been likened by epidermological writers to that of vinegar, rancid oil, mouldiness, and rotten straw; this last comparison being, in our opinion, the most accurate. This variety of perspiration ferments very easily, and hence has been described as smelling like "spoiled vinegar."

We now come to the cutaneous odors connected with the eruptive fevers. Hebra quotes Heim, of Berlin, as maintaining that each of these complaints has its peculiar odor, recognizable by the experienced physician. In measles, we have the smell of feathers freshly plucked; in scarlatina, that of bread hot from the oven; in small-pox, that of the yellow deer or of a menagerie. These odors, in Hebra's opinion, "are not pronounced enough to be regarded as characteristic," a criticism which we do not consider altogether just. Some of Heim's picturesque comparisons may perhaps be drawn from his imagination, but there is certainly a marked difference between the cutaneous odor in the suppurative stage of variola and that in a case of measles.

Skin diseases of whatever kind, when seated on the genital organs or the anus, between the toes or in the axillæ, exhale the odors peculiar to their respective localities, but with a still higher degree of fetidity. Scrofulous sores, lymphatic dermatoses, eczema, impetigo, *croutes de gourmes*, etc., have a feebly acid or mouldy smell. Sebaceous acne exhales a nauseous, rancid odor, which is *sui generis*. *Eczema pillaris* has a repulsive fetidity, probably due to retention of extravasated products. Rupia is not only of hideous aspect, owing to its scabs and purulent exudations, but is prominently characterized by its offensive odor. Pemphigus discharges a serum which normally has an insipid smell. When this changes to gangrenous, it announces the appearance of a malignant septicæmic form of the accompanying fever.

The odors of impetigo, of rupia, etc., are doubtless derived from the decomposition of the muco-purulent secretions, in those diseases, and from the maceration of the exfoliated scabs in the altered fluids of the pustulous bullæ.

The *hair* possesses a normal odor which is peculiar, but scarcely definable. It varies in different races; the hair of the Chinese, as is well known, has a natural smell of musk, which cannot be washed off even with the aid of strong chemicals.

Hairs lose their odor after falling off. Barbers can tell at once, by simply smelling at a lock, whether it was cut from the living head or made up from combings.

In hysteria, and especially in hystero-epilepsy, the hair takes on, during the paroxysm, a specific odor which is always the same, and resembles that of ozone.

In tinea favosa, the odor of the scalp affords a valuable diagnostic indication well known to all dermatologists. Offensive and nauseating, it has been compared to the smell from a nest of mice, to that of cat's urine, and to marshy effluvia. It grows worse as long as the disease continues, but may be lessened, though never entirely got rid of, by attention to cleanliness. It is eminently characteristic of the complaint, and after having been once recognized, can never be mistaken.

This odor is entirely distinct from that of the pseudotineæ, especially the *tinea granulosa* of Alibert, which is a simple impetigo of the scalp, frequently offensive, but smelling like sour milk, not at all like mice.—*E. Monin, Sur les Odeurs du Corps Humain, Prize essay, Paris*, 1885; *(Ann. d. l. Soc. de Med. d'Anvers)*; *Journal of Cutaneous Diseases.*

AN IMPROVED CALORIMETER FOR FUEL.

An appliance, based on the lines of the older forms of calorimeter, but so designed as to admit of the use of larger quantities (say 80 to 100 grains) of the fuel to be tested than has hitherto been practicable, has lately been designed and used by Schwackhofer. It comprises several improvements in detail, some of a most ingenious character, for facility in working, the securing of complete combustion, and for accuracy in results. Two peculiarly shaped vessels of platinum are used for containing the combustible; and these are inclosed in a copper jacket, which in its turn is surrounded by a vessel to be filled with water, which constitutes the calorimeter proper. To prevent loss of heat by radiation, etc., the calorimeter is surrounded by a layer of eider-down, a second water vessel, another layer of down, and a wooden case, which forms the outer covering of the instrument. From the combustion chamber, a coiled tube passes; and this is connected to a system of two aspirators (one large and one small), which serve to maintain a current of air or oxygen through the apparatus during the combustion, and also to collect for examination the products of combustion. The combustion vessel is double, being divided into two parts—the upper and the lower—each capable of receiving a charge of combustible; and there are four tubes for supplying air or oxygen, either above or below the fuel, as may be desirable. Two of these tubes are made sufficiently large in bore to enable an observation to be taken, by means of small mirrors fixed in suitable positions, of the interior of each vessel respectively, so as to ascertain whether combustion is proceeding or otherwise. A series of ten thermometers is used for taking the necessary temperatures, including that of the external air, the calorimeter, the external water vessel, the cover, and the incoming oxygen. A mechanical stirrer is provided for agitating the water in the calorimeter. The method of procedure (which, in a general way, is similar to that usual with instruments of this kind) is given in detail. The author has made a number of calorimeter observations which agree well together, and are somewhat higher than the value calculated by Dulong's formula from the percentage composition.

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TABLE OF CONTENTS OF

THE SCIENTIFIC AMERICAN SUPPLEMENT

No. 502,

For the Week Ending August 15, 1885.

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